ROTATIONAL CROPPING AFTER APPLYING EXPERIMENTAL HERBICIDES FOR WEED CONTROL IN SOYBEANS

by

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INTRODUCTION

Kansas farmers planted 1.5 million acres of soybeans [Glycine max (L.) Merr.] in 1985(3). Many of these acres are rotated with hard red winter wheat (Triticum aestivum L.) and grain sorghum [Sorghum bicolor (L.) Moench]. Broadleaf weed control in soybeans has been a considerable problem for many growers partially due to a limited selection of available herbicides. Metribuzin has been the primary broadleaf herbicide used. During the early 1980's several chemical companies started testing new compounds that have some exciting new possibilities. These herbicides are Imazaquin (trade name, Scepter from American Cyanamid); AC 263,499 (trade name, Pursuit also from American Cyanamid); FMC 57020 (trade name Command from FMC), Cinmethylin (trade name, Cinch from Du Pont); Chlorimuron-ethyl (trade name, Classic from Du Pont); and DPX-L8347 (a product mix of chlorimuron-ethyl and metribuzin with trade name Canopy from Du Pont). All five new compounds come from entirely new families of chemistry and most are primarily broadleaf herbicides. Advantages these new compounds offer include wide margins of crop safety, control of specific hard to control weeds, low mammalian toxicity levels, and a wide range of tank mixing

possibilities for broad spectrum weed control. The major disadvantage is their long persistence in the soil which can prevent crop rotations. So this research project was designed to test these six new herbicides over a variety of eastern Kansas conditions. Objectives were to evaluate the weed control efficacy, to determine the soybean tolerance, and to determine the carry-over potential to winter wheat and grain sorghum grown in rotation. Primary emphasis was placed on carry-over to rotational crops.

LITERATURE REVIEW

Commercial sales of Imazaquin "Scepter," Clomazone "Command," and Chlorimuron-ethyl "Classic" began in 1986. Imazethapyr "Pursuit" and Cinmethylin "Cinch" have not yet received label registration. Considerable research has been done on the weed control efficacy and crop safety of these herbicides; however, uncertainty still exists with the factors that influence the persistence of these herbicides in the soil.

HERBICIDAL PROPERTIES

Imazaquin

Imazaquin is a member of the new family of chemistry called the imidazolinones. Compounds from this chemistry inhibit the first enzyme, acetohydroxacid synthase, in the reaction chain needed to produce the amino acids, valine, isoleucine, and leucine. Since the young growing parts of plants need large amounts of amino acids for cell division, susceptible plants stop growing and die slowly. Because the more mature parts of the plant are not growing rapidly and have reserves of amino acids, the herbicidal effects will be less apparent in these areas. The herbicide is readily absorbed by roots and foliage, translocated through both

phloem and xylem, and accumulates in the meristematic tissue. Shaner et al.(32) found that the basis for selectivity between susceptible and tolerant plants occurred by differential metabolism of the herbicide, once inside the plant. Because imazaquin inhibits formation of amino acids that are produced only in plants, and because mammals rapidly excrete the chemical, it has a low toxicity to mammals(8, 25).

<u>Imazethapyr</u>

Because imazethapyr, like imazaquin, is from the imidazolinone family of chemistry, the mode of action and properties are the same as for imazaquin(25).

<u>Clomazone</u>

Clomazone also emerges from new chemistry. This compound is absorbed by both roots and shoots, transported through the xylem to the leaves, and then it inhibits biosynthesis of chlorophyll and carotenoids in susceptible species. Susceptible plants emerge without pigment and soon die. The basis of selectivity between tolerant and susceptible species appears to be differential metabolism of the herbicide(12).

<u>Cinmethylin</u>

Cinmethylin is the only herbicide in this study that is primarily a grass herbicide. The compound is of a unique chemistry class, called cineole, which is composed of only

carbon, hydrogen, and oxygen. Because of its structure, it has a low mammalian toxicity level. Cinmethylin inhibits growth in the meristematic tissue of roots and shoots of susceptible species. El-Deek and Hess(11) found this specifically to be an inhibition of the entry of cells into mitosis, thus restricting cell division. The herbicide is absorbed by shoots and roots of emerging plants and translocated primarily to the shoot meristem by the phloem (18, 25).

Chlorimuron-ethyl

Chlorimuron-ethyl is a part of a relatively new class of herbicides, called the sulfonylureas from which many new products are being developed. Chlorimuron-ethyl rapidly inhibits growth and causes slow death in susceptible plants. The specific cause of growth inhibition is a block of valine and isoleucine production by inhibiting the enzyme acetolactate synthase. This is the same enzyme inhibited by the imidazolinones. The basis of herbicide selectivity is metabolic inactivation of the compound by the tolerant soybean plant. The herbicide is taken up by roots and shoots. Chlorimuron-ethyl also has a low toxicity level to mammals(7).

WEED CONTROL

Imazaquin

Croon and Slife(9) found common cockelbur (Xanthium pensylvanicum L.) and pigweed (Amaranthus sp.) to be highly sensitive to imazaquin applied preplant incorporated (PPI), preemergence (PRE), and postemergence (PE), giving near 100% control with all three application methods. They achieved good control of velvetleaf (Abutilon theophrasti Medik.) and giant foxtail (Setaria faberi Herrm.) with PRE and PPI applications; however, PE applications were not as effective. They reported better control of tall morningglory [Ipomoea purpurea (L.) Roth] and ivyleaf morningglory [Ipomoea hederacea (L.) Jacq.] with imazaquin than metribuzin, both soil applied, and equal control of these species as acifluorfen or bentazon. Kapusta(20) found imazaquin to give complete control of common lambsquarters (Chenopodium album L.) and Pennslyvania smartweed (Polygonum pensylvanicum L.) but variable control of velvetleaf. Other research indicates similar activity of imazaquin.

Imazethapyr

The spectrum of weed control with imazethapyr is similar to imazaquin but differences do exist. Thelen and Kells(34) found imazethapyr to give better velvetleaf control than did imazaquin. In data summarized from studies

in the North Central States in 1982 to 1985, Sanborn et al. (31) reported all three application methods (PRE, PPI, and PE) of 70 g/ha to 140 g/ha of imazethapyr giving good to excellent control of Eastern black nightshade (Solanum ptycanthum Dun.), common ragweed (Ambrosia artemisiifolia L.), Pennsylvania smartweed, redroot pigweed (Amaranthus retroflexus L.), velvetleaf, and giant foxtail. PE control of cockelbur was good to excellent; however, with soil applications control was only fair. Comparatively, imazaquin gives better cockelbur control, but imazethapyr provides better velvetleaf control. In conclusion, imazethapyr appears to have a wide spectrum of activity and potential timings of application.

Clomazone

Clomazone "controls species such as velvetleaf and jimsonweed (Datura stramonium L.) which are often not adequately controlled by existing soybean herbicides either alone or in combinations," according to Warfield et al. (39) Warfield et al. (38), in summarizing results from experimental use permit (EUP) plots in 24 states, reports that clomazone gives broad spectrum control of many annual broadleaf and grassy weeds and shows promising activity on several perennial species. Excellent control was recorded on these grass species: foxtail sp., barnyard grass [Echinochola crus-galli (L.) Beauv.], crabgrass sp.

(Digitaria sp.), and fall panicum (Panicum dichotomiflorum Michx.). They also reported control of velvetleaf, jimsonweed, lambsquarters, prickly sida (Sida spinosa L.), common ragweed, venice mallow (Hibiscus trionum L.), spotted spurge (Euphorbia maculata L.), and prostrate spurge (Euphorbia humistrata Engelm. ex Gray). They also confirmed control of pitted morningglory (Ipomoea lacunosa L.) and common cocklebur. Bellman et al.(5) observed that clomazone has some activity on perennials, but does not give complete control of species such as quackgrass [Agronpyron repens (L.) Beauv.] and rhizome johnsongrass [Sorghum halapense (L.) Pers.].

Cinmethylin

Cinmethylin has been tested as a soil-applied grass herbicide. Price and May(26) reported cinmethylin to control most members of the Setaria, Panicum, Digitaria, and Echinochloa genera which include the foxtails, fall panicum, crabgrass, and barnyardgrass. They also observed that cinmethylin controled two hard to control weeds, wild proso millet (Panicum miliaceum L.) and shattercane [Sorghum bicolor (L.) Moench].

Chlorimuron-ethyl

Chlorimuron-ethyl has both foliar and soil activity at very low use rates and is being sold as a PE broadleaf herbicide and as product mixes with metribuzin or linuron as

soil applied broadleaf herbicides. Claus(7) stated that chlorimuron-ethyl, PE, is effective in controlling cockelbur, pigweed, common sunflower (Helianthus annuus L.) and morningglory sp. DPX-L8347 is the experimental number for a product mix of chlorimuron-ethyl and metribuzin in a 1:6 ratio. Gorrel et al.(17) in summarizing results from tests in the North Central States, reported that the addition of metribuzin to chlorimuron-ethyl improves the PRE control of prickly sida, velvetleaf and morningglory.

CROP SAFETY

Most broadleaf soybean herbicides have had a narrow margin of safety, because of the similarity between broadleaf weeds and the soybean crop. These new products have been shown to have, in most cases, a wide margin of selectivity resulting in good crop safety. Imazaquin was shown to have excellent crop safety with over 90% of the 1985 EUP plots in the North Central Region showing no observable injury as reported by Nau et al.(24). Of the few cases where injury was reported, it was generally slight and symptoms soon disappeared. Sanborn et al.(31) reported from tests in 1982 through 1985 that soybean injury caused by imazethapyr at all tested rates and application timings was negligible. Clomazone was shown to have a 4X (4 times the

usage rate) crop tolerance applied either PPI or PRE by Bellman et al.(5). However, some initial phytotoxicity to soybeans has been observed with deeply incorporated treatments of cinmethylin in tests conducted in the North Central Region by Price et al(27). Gorrell et al.(17) report that crop safety with chlorimuron-ethyl is acceptable, but some leaf discoloration was observed at higher PE and PRE rates.

HERBICIDE PERSISTENCE

Herbicide carry-over and resulting injury to sensitive rotational crops has been an area of considerable concern with all these compounds except cinmethylin. Research has shown that carry-over does not occur in most conditions with cinmethylin(22). For this reason, cinmethylin will not be discussed in this section. Imazaquin, imazethapyr, clomazone, and chlorimuron-ethyl all have been shown to cause carry-over injury to rotational crops. Crops of primary concern are corn (Zea mays L.), grain sorghum, wheat, and cotton (Gossypium hirsutum L.). Little work has been done to determine the soil and environmental factors that can influence the persistence of these herbicides. Because of the popularity of crop rotations with soybeans,

the area of herbicide persistence is of great importance in the success of these herbicides.

Imazaquin

The federal label for imazaquin has given recropping intervals (time between application of the herbicide and planting of a rotational crop) needed to protect against carry-over injury to rotational crops. According to the latest published label, recropping intervals are 4 months for wheat, 11 months for corn, 11 months for grain sorghum, and 18 months for cotton(1). However, Renner and Meggitt (30) observed injury to corn planted 11 months after imazaquin application. Some work has been done to quantify the soil and environmental factors responsible for differences in imazaquin persistence in the soil. Differences in pH, organic matter content (OM), clay minerals, and moisture levels of soil have been researched as possible factors reponsible for differences in imazaquin carry-over(24). However, the results to date indicate that soil texture and method of application are the only factors that can conclusively account for differences in imazaquin carry-over(4, 29). Renner(4) observed that PPI treatments were more persistent than PRE treatments. Basham et al.(4) and Loux(21) both found imazaquin persistence to be greater in finer textured soils than medium textured soils. Renner

(29) also found a difference among corn varieties in their tolerance to imazaquin.

Imazethapyr

Imazethapyr shows some differences compared to imazaquin concerning carry-over. Renner(29) found imazethapyr to be less phytotoxic to corn than imazaquin. In summarizing field studies from 1983 - 1986, Ballard et al.(2) observed rotational grain sorghum to be sensitive to 0.071 kg/ha of imazethapyr but rotational corn and wheat to be tolerant to 0.14 kg/ha of imazethapyr. The same factors that effected the length of herbicide persistence with imazaquin have been shown to effect imazethapyr persistence. Loux(21) found imazethapyr to persist longer in a silty clay loam than in a silt loam. PPI and PE applications were shown to cause greater carry-over injury than PRE applications(6). Currently, soil texture and application method are the only two factors that have been conclusively shown to have an effect upon the length of carry-over of these two imidazolinone herbicides(4, 29)

Clomazone

Clomazone has been shown to cause up to an 80% yield reduction to winter wheat planted in the fall following soybeans treated in the spring(35). So, the carry-over injury from clomazone can be quite striking. According to the federal label approved in 1986 for clomazone, wheat can

be planted one year after treatment of labeled rates, and a 9 month wait is required for corn and grain sorghum(13). Soil type has been shown to have an influence upon soil degradation of clomazone by Froelich et al.(15). Because of varying amounts of carry-over, attempts have been made to quantify the factors responsible for differences. Loux(21) found the dissipation rate of clomazone to be slower in high organic matter, fine textured soils than in medium textured soils. In the two soils he studied, there was a positive correlation between dissipation rate and bioavailability. So, lighter soils would have greater bioavailability but shorter persistence than heavier soils.

Another area of concern with clomazone is off-target movement following application which has injured susceptible species. Halstead and Harvey(19) reported this movement to be from volatilization rather than from physical drift. They found wet soil, residue on soil surface, and surface application to greatly increase volatilization. This is supported by Thelen et al.(37). They also found PPI treatments to cause greater carry-over injury than PRE.

<u>Chlorimuron-ethyl</u>

PRE and PE applications of chlorimuron-ethyl have shown carry-over injury to corn in high pH soil(16). Chlorsulfuron, used for broadleaf control in wheat, can

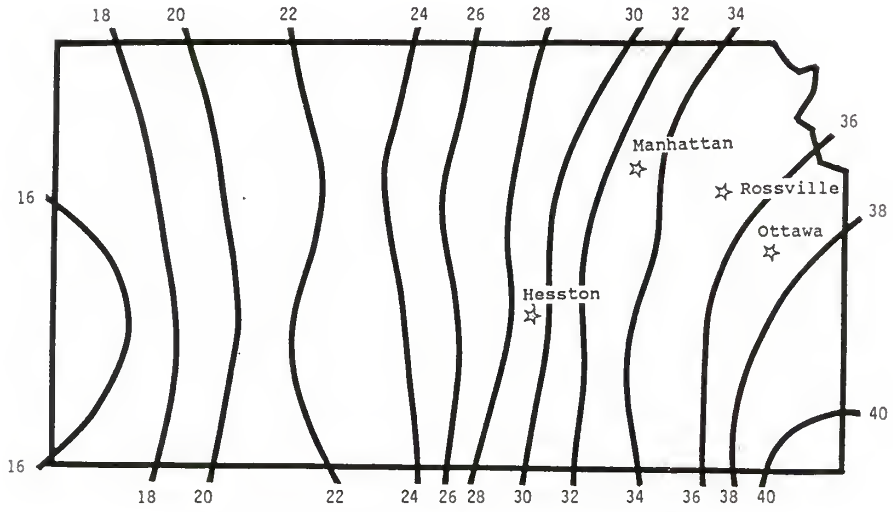
cause carry-over injury to grain sorghum and soybeans. Peterson and Arnold(28) found carry-over injury with chlorsulfuron to be correlated with pH and OM. Because of the similarity of chemical nature between chlorsulfuron and chlorimuron-ethyl, the same factors affect the length of persistence for each herbicide. Chemical hydrolysis and microbial decomposition have been shown to be the major methods of chlorimuron-ethyl dissipation. The rate of chemical hydrolysis in the soil is influenced largely by soil pH and soil temperature. Warm, moist soil favors microbial decomposition. Accordingly, conditions unfavorable for herbicide breakdown provide the most opportunity for herbicide carry-over. These conditions favoring chlorimuron-ethyl carry-over include high pH, low soil temperatures and low rainfall. Corn, grain sorghum, cotton, and rice (Oryza sativa L.) are crops sensitive to chlorimuron-ethyl(7). Federal label registration, received in 1986, gave recropping intervals of 3 months for wheat and 9 months for corn and grain sorghum(10).

MATERIALS AND METHODS

Field research plots were established in May of 1985 at four locations in east and central Kansas. Considerable soil and weather variations exist between sites at Ashland Agronomy Farm near Manhattan, Kansas River Valley Experiment Field near Rossville, East Central Experiment Field near Ottawa, and Harvey County Experiment Field near Hesston. Table 1 shows the respective soil conditions and average rainfall for each location. Hereafter, sites will be referred to as Manhattan, Rossville, Ottawa, and Hesston. All field work at the Rossville, Ottawa, and Hesston experiment fields was done by experiment field personnel. Year 1 refers to soybeans planted in 1985 and rotational crops on the same plot area in 1986 and 1987. Year 2 refers to soybeans planted in 1986 and rotational crops on the same plot area in 1987.

Twenty-four herbicide treatments were applied to soybeans in 3.0 meter (m) X 9.1 m plots in two years, 1985 and 1986. Three replications were made in a randomized complete block design. All 5 compounds being tested were applied PRE at 1,2, and 3 times their expected label usage rate. Also, a 50-75% reduced rate was used in combination with another herbicide to see how low a rate could be used

Table 1: Location, rainfall, soil type, pH, and organic matter content for each site.



NORMAL ANNUAL PRECIPITATION FOR KANSAS, 1951-1980

Location	Soil type	pH	OM %
Manhattan	Reading silt loam	6.7	2.0
Ottawa			
Year 1	Woodson silt loam	6.0	2.9
Year 2		6.5	3.2
Rossville			
Year 1	Eudora silt loam	6.0	1.4
Year 2	Sarpy fine sandy loam	7.4	1.1
Hesston			
Year 1	Ladysmith silty clay loam	5.5	1.9
Year 2	Geary silt loam	6.0	2.2

and still get good weed control but reduce the carry-over potential. DPX - L8347 was applied at rates within the label usage rate. Rates and combinations are given on the treatment list (Table 2). A standard treatment of alachlor + metribuzin was also included in the 24 herbicide treatments. Acifluorfen was applied to plots treated with cinmethylin to control broadleaf weeds since cinmethylin primarily controls grassy weed activity. Alachlor was added to chlorimuron-ethyl and DPX-L8347 to control grassy weeds. The 0.14 kg/ha rate of imazethapyr, which is the 1X rate in this study, is slightly higher than the expected usage rate. Treatments were applied with compressed-air tractor-mounted plot sprayers at 188 liters/ha using water as the carrier.

Visual crop injury and weed control ratings were taken at each location. Visual crop injury was rated on the basis of 0 = no injury and 10 = complete kill. Visual weed control ratings were taken for each individual weed species and overall ratings for grass and broadleaf weeds. Weed control ratings were made on the basis of no weed control = 0 and no weeds present in the plot = 10. A rating of 10 may or may not be the result of the herbicide treatment. Soybean yields were also taken to reflect any crop injury. Crop height measurements were taken on some plots to further indicate crop injury.

Table 2: Herbicide treatment list.

No.	Herbicide Treatments	Kg A.I.* per Ha	When Applied
1.	Imazaquin	0.14	PRE
2.	Imazaquin	0.28	PRE
3.	Imazaquin	0.43	PRE
4.	Imazaquin + Metribuzin	0.071 + 0.28	PRE
5.	Imazethapyr	0.14	PRE
6.	Imazethapyr	0.28	PRE
7.	Imazethapyr	0.43	PRE
8.	Imazethapyr + Imazaquin	0.071 + 0.14	PRE
9.	Clomazone	1.1	PRE
10.	Clomazone	2.2	PRE
11.	Clomazone	3.4	PRE
12.	Clomazone + Imazaquin	0.84 + 0.071	PRE
13.	Clomazone + Metribuzin	0.84 + 0.28	PRE
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	PRE
15.	Cinmethylin (2.2 Acifluorfen + 0.5 % surfactant PE)	1.3	PRE
16.	Cinmethylin (2.2 Acifluorfen + 0.5 % surfactant PE)	2.7	PRE
17.	Cinmethylin (2.2 Acifluorfen + 0.5 % surfactant PE)	4.0	PRE
18.	Cinmethylin + Imazaquin	1.1 + 0.071	PRE
19.	Chlorimuron-ethyl + Alachlor	8.7 g + 2.2	PRE
20.	Chlorimuron-ethyl + Alachlor	17.5 g + 2.2	PRE
21.	Chlorimuron-ethyl + Alachlor	26.3 g + 2.2	PRE
22.	DPX-L8347 + Alachlor	0.42 + 2.2	PRE
23.	DPX-L8347 + Alachlor	0.84 + 2.2	PRE
24.	Standard (0.28 Metribuzin + 2.2 Alachlor)		PRE

*A.I. = Active Ingredient

Following soybean harvest, several different recropping sequences followed involving winter wheat planted in October and/or grain sorghum planted in June or July. Visual crop injury ratings were taken for each rotational crop in the same manner as with the soybeans. All harvesting was done with modified Gleaner "E" plot combines. With soybeans and grain sorghum, the center two rows were harvested for yield from each 4 row plot. For wheat, 1.8 meters were harvested for yield from the center of each 4 m wide plot. Grain moisture and test weight samples were taken for each plot at most locations.

Statistical analysis was performed on weed control ratings, crop injury ratings, yield, grain moisture, grain test weight, and crop height, where taken. Analysis of variance procedure was used and treatment mean separation was performed using Fisher's protected least significant difference method with alpha = 0.05.

Individual rotational sequences, cultural practices and soil characterizations are given by location as follows.

<u>Manhattan</u>

The site near Manhattan is on bottom land soils in the Kansas River valley. The Reading silt loam soil is a fine, mixed, mesic, typic Argiudoll. Plots were irrigated with a

linear-move sprinkler system. In 1985, a second weed control rating was taken on October 17 for smooth ground cherry (Physalis subglabrata Mackenz. & Bush). Soybean height readings were taken on 16 October, 1985, and wheat height readings were taken on 22 May, 1986, and 19 May, 1987, and grain sorghum height readings were taken on 8 October, 1986. The recropping sequence for both years was soybeans - wheat - double-cropped grain sorghum. Other information is in Tables 3 to 5.

Rossville

The Rossville site is also on bottom land soils in the Kansas River Valley. Eudora silt loam soil is a coarse-silty, mixed, mesic, Fluventic Hapludoll. Sarpy fine sandy loam is characterized as a sandy, mixed, mesic, typic Udipsamment. The Year 2 site was irrigated with a linear-move sprinkler irrigation system. The recropping sequence for Year 1 was soybeans - wheat and for Year 2 was soybeans - wheat - double-cropped grain sorghum. See Tables 6 to 8.

Table 3: Methods for soybeans at Manhattan.

	Year 1 (85)	Year 2 (86)
Seedbed preparation	Lely "roterra"	No-till
Planter used	John Deere "Max-Emerge"	
row spacing	76 cm	
Planting date	5/21/85	5/20/86
rate	67 kg/ha	67 kg/ha
depth	3 cm	3 cm
Variety	Sparks	Williams 82
PRE application date	5/21/85	5/20/86
nozzle used	SS8004	SS8004
pressure	1.3 kg/cm^2	1.1 kg/cm^2
Post application date	6/19/85	6/13/86
Rating date	7/3/85	6/27/86 and 7/2/86
Irrigation	3.3 cm	6.4 cm
Harvest date	10/24/85	9/26/86

cm = centimeter

Table 4: Methods for wheat at Manhattan.

	Year 1 (85-86)	Year 2 (86-87)
Seedbed preparation	Lely "roterra"	No-till
Drill used	GT[1] no-till	
row spacing	25 cm	
Planting date	10/26/85	10/21/86
rate	135 kg/ha	90 kg/ha
depth	2.5 cm	2.5 cm
Variety	Newton	Arkan
Fertilizer	67-56-0 kg/ha broadcast as 34-0-0 and 18-46-0	
date applied	10/26/85	10/21/86
Rating date		
crop injury	4/11/86	3/12/87
Harvest date	6/20/86	6/22/87

[1] GT is a trade mark of Gilmore-Tate Manufacting Co.

Table 5: Methods for grain sorghum at Manhattan.

	Year 1 (86)	Year 2 (87)
Seedbed preparation	No-till	No-till
Planter used	John Deere "Max-Emerge"	
row spacing	76 cm	
Planting date	6/20/86	6/23/87
rate	98,800 seeds/ha	
depth	3 cm	3 cm
Variety	NK 2660	Asgrow Topaz
Insecticide	Furadan	Furadan
Herbicide (kg/ha)	2.9 alachlor + 1.4 glyphosate + 1.0 2,4-D	2.9 alachlor + 1.4 glyphosate
date applied	6/20/86	6/23/87
		2.0 atrazine 7/15/87
Fertilizer	100 kg N/ha banded in row as 28-0-0	112 kg N/ha broadcast as 34-0-0
date applied	7/23/86	6/23/87
Rating date Crop injury	7/9/86	7/17/87
Irrigation	9.6 cm	10 cm
Harvest date	10/30/86	10/5/87

N = nitrogen

Table 6: Methods for soybeans at Rossville.

	Year 1 (85)	Year 2 (86)
Seedbed preparation	Disk	Disk
Planter used	John Deere "Max Emerge"	
row spacing	76 cm	
Planting date	5/17/85	5/22/86
rate	33 seeds/m of row	
depth	2 cm	2 cm
Variety	Sparks	Sherman
PRE application date	5/18/85	5/22/86
nozzle used	SS8004	SS8004
pressure	1.8 kg/cm^2	1.8 kg/cm^2
Post application date	6/26/85	6/10/86
Rating date	7/12/85	6/18/86
Irrigation	none	5.2 cm
Harvest date	10/8/85	10/7/86

Table 7: Methods for wheat at Rossville.

	Year 1 (85-86)	Year 2 (86-87)
Seedbed preparation	Disk	Disk
Drill used	Marlis No-till	
row spacing	19 cm	
Planting date	10/17/85	10/10/86
rate	100 kg/ha	100 kg/ha
depth	3 cm	3 cm
Variety	Newton	Siouxland
Fertilizer	93-36-18 kg/ha as 8-32-16 broadcast	104-52-0 kg/ha as 18-46-0 broadcast
	and 34-0-0 topdressed	and 34-0-0 topdressed
dates applied	10/17/85 3/26/86	10/10/86 2/3/86
Rating date		
crop injury	3/20/86	3/11/87
Harvest date	6/18/86	6/22/87

Table 8: Methods for grain sorghum at Rossville.

	Year 2 (87)
Seedbed preparation	Disk
Planter used	John Deere "Max Emerge"
row spacing	76 cm
Planting date	6/26/87
rate	6.6 kg/ha
depth	2.5 cm
Variety	NC+ 271
Insecticide	none
Herbicide (kg/ha)	1.5 atrazine + 2.2 alachlor
date applied	6/26/87
Fertilizer	102-27-9 kg/ha as 8-24-8 at planting and 82-0-0 sidedressed
dates applied	6/26/87 and 7/22/87
Rating date	
Crop injury	8/5/87
Irrigation	11.8 cm
Harvest date	10/15/87

Ottawa

The Ottawa site is an upland, dryland site. Woodson silt loam is a fine, montmorillonitic, thermic, Abruptic Argiaquoll. Due to wet fall seasons in 1985 and 1986, wheat was not planted as a rotational crop. So, full season grain sorghum was planted both years to evaluate herbicide carry-over. Plot size at this site was 3 m X 15 m. See Tables 9 and 10.

Hesston

The Hesston site is on upland, dryland soils. Ladysmith silty clay loam is classified as a fine, montmorillonitic, mesic, Pachic Argiustoll; and Geary silt loam is a fine-silty, mixed, mesic, Udic Argiustoll. The recropping sequence here was soybeans - wheat - double-cropped grain sorghum for both years. Due to extensive herbicide carryover, the Year 1 plot was planted to grain sorghum again in 1987 to check for carry-over into a second year after application. Refer to tables 11 - 14.

Table 9: Methods for soybeans at Ottawa.

	Year 1 (85)	Year 2 (86)
Seedbed preparation	Field cultivate	
Planter used	White 5100 air planter	
row spacing	76 cm	
Planting date	6/21/85	5/27/86
rate	26 seeds/m of row	
depth	2.5 cm	2.5 cm
Variety	Williams 82	Williams 82
PRE application date	6/21/85	5/27/86
nozzle used	SS8002	SS8004
pressure	1.9 kg/cm^2	1.8 kg/cm^2
Post application date	7/23/85	6/19/86
Rating dates		
Crop injury	7/18/85	7/10/86
Weed control	8/5/85	7/10/86
Harvest date	11/7/85	12/10/86

Table 10: Methods for grain sorghum at Ottawa.

	Year 1 (86)	Year 2 (87)
Seedbed preparation	Field cultivate	
Planter used	White 5100 air planter	
row spacing	76 cm	
Planting date	6/3/86	5/21/87
rate	10 seeds/m of row	
depth	2.5 cm	2.5 cm
Variety	NC+ 174	Garrison SG922
Insecticide	none	none
Herbicide (kg/ha)	3.4 propachlor + 1.1 atrazine	2.2 alachlor + 1.1 atrazine
date applied	6/3/87	5/21/87
Fertilizer	97-54-27 kg/ha as 8-32-16 and 34-0-0 broadcast	103-54-27 kg/ha as 8-32-16 and 34-0-0 broadcast
dates applied	3/24/86 5/23/86	4/24/87 4/27/87
Rating date		
Crop injury	7/18/86	8/18/87
Harvest date	12/30 and 12/31/86	9/22/87

Table 11: Methods for soybeans at Hesston.

	Year 1 (85)	Year 2 (86)
Seedbed preparation	Field cultivate	
Planter used	White 5100 air planter	
row spacing	76 cm	
Planting date	6/15/85	6/13/86
rate	33 seeds/m of row	
depth	3.8 cm	3.8 cm
Variety	Cumberland	Sparks
PRE application date	6/15/85	6/13/86
nozzle used	SS8003	SS8003
pressure	1.8 kg/cm^2	1.5 kg/cm^2
Post application date	not applied	7/10/86
Rating date	7/18/85	7/18/86
Harvest date	10/24/85	10/20/86

Table 12: Methods for wheat at Hesston.

	Year 1 (85-86)	Year 2 (86-87)
Seedbed preparation	No-till	No-till
Drill used row spacing	Crustbuster No-till 20 cm	
Planting date rate depth	10/28/85 87 kg/ha 2.5 cm	10/30/86 90 kg/ha 2.5 cm
Variety	Arkan	Arkan
Fertilizer	60-36-0 kg/ha as 18-46-0 with seed and 34-0-0 broadcast	68-36-0 kg/ha as 18-46-0 with seed and 34-0-0 broadcast
dates applied	10/28/85 3/7/86	10/30/86 10/30/86
Crop injury rating date	4/14/86	4/10/87
Harvest date	6/19/86	6/24/87

Table 13: Methods for grain sorghum at Hesston.

	Year 1 (86)	Year 2 (87)
Seedbed preparation	No-till	No-till
Planter used	White 5100 air planter	
row spacing	76 cm	
Planting date	6/30/86	7/10/87
rate	94,000 seeds/ha	98,800 seeds/ha
depth	3.8 cm	2.5 cm
Variety	Funk's G-1498	
Insecticide	9.8 kg/ha Furadan	
Herbicide (kg/ha)	1.7 glyphosate + 0.8 ammonium sulfate + 0.5 % surfactant	3.2 glyphosate + 2.9 alachlor + 0.8 ammonium sulfate + 0.5 % surfactant
date applied	6/28/86	7/10/87
	2.9 alachlor + 1.4 glyphosate + 0.6 atrazine 6/30/87	1.1 glyphosate + 0.5 % surfactant 7/10/87
		0.6 atrazine 7/10/87
Fertilizer	none	78 kg/ha N as 34-0-0 broadcast
date applied		7/10/87
Rating date crop injury	7/18/86	8/6/87
Harvest date	11/13/86	11/19/87

Table 14: Methods for second-year grain sorghum at Hesston.

	Year 1 (87)
Seedbed preparation	Field cultivate
Planter used	White 5100 air planter
row spacing	76 cm
Planting date	6/24/87
rate	98,800 seeds/ha
depth	2.5 cm
Variety	Funk's G-1498
Insecticide	9.8 kg/ha Furdan
Herbicide (kg/ha)	3.4 propachlor + 1.1 atrazine
date applied	6/24/87
Fertilizer	78 kg/ha N broadcast as 34-0-0 6/17/87
Rating date	
Crop injury	8/6/87
Harvest date	11/5/87

Greenhouse

A greenhouse study was conducted in March 1986 to look for differences in wheat cultivar tolerance to clomazone. Muir silt loam topsoil was finely ground with a machine-powered flail-type grinder. Four wooden trays, each containing 8.9 kg of soil 6.9 cm deep were sprayed using a track-type greenhouse sprayer. Clomazone was applied at a rate of 0.061 kg/ha with a flat fan SS 8001 nozzle at 1.3 kg/cm^2 pressure. The soil was thoroughly hand-mixed. Peat was placed in the bottom of small growth tubes. Tubes were filled 3/4 full with the treated soil. Three wheat seeds were planted in each tube and 2 cm of sand was placed on top of the soil in each tube. Forty-one cultivars were used, each replicated 4 times and arranged in trays in a completely randomized method. Trays of tubes were subirrigated. Two weeks after planting, plants were visually evaluated for tolerance to clomazone on the basis of the degree of leaf whiteness. Statistical analysis was not performed because no differences could be visually detected. Table 15 shows the wheat cultivars used in the study.

Table 15: Wheat cultivars in greenhouse study.

1.	Agri Pro Mustang	22.	KS 82 H4
2.	Agri Pro Ram	23.	KS 82 H144
3.	Agri Pro Stallion	24.	KS 82 1957
4.	Agri Pro Thunderbird	25.	Larned
5.	Agri Pro Wrangler	26.	Newton
6.	Agri Pro Victory	27.	DK 81332
7.	AGC 102	28.	Pike
8.	Arkan	29.	Pony
9.	Brule	30.	Pro Brand 830
10.	Brule Comp	31.	RHS R 7833
11.	Bounty 202	32.	RHS R 7837
12.	Bounty 205	33.	Scout 66d
13.	Bounty 301	34.	Siouxland
14.	Bounty Exp 2222	35.	Super B
15.	Caldwell	36.	Super T
16.	Centura	37.	Tam 105
17.	Centurk 78	38.	Tam 107
18.	Chisholm	39.	Tam 108
19.	Colt	40.	Triumph 64
20.	Garst HR 48	41.	Vona
21.	Garst HR 64		

RESULTS AND DISCUSSION

WEED CONTROL

Individual weed species present in plots were rated for control at each location, and an overall rating for grass and broadleaf control was given at most locations.

Manhattan

Weed pressure was generally light both years at Manhattan. Weed species rated for both years include pigweed species, carpetweed (Mollugo verticillata L.), puncturevine (Tribulus terrestis L.), and smooth ground cherry. In 1985, honeyvine milkweed [Ampelanus albidus (Nutt.) Britt.] was also rated. Eastern black nightshade and morningglory sp. were rated in 1986. See Tables 16 to 20.

Significant statistical differences in weed control were observed both years with pigweed, carpetweed, puncturevine, and the overall broadleaf rating. Both the 3 July and 17 October ratings indicated significantly different control of smooth ground cherry between treatments. In 1986, significant differences were observed between treatments with Eastern black nightshade.

Table 16: 1985 Manhattan overall broadleaf and grass ratings.

No.	Herbicide Treatment	Kg A.I. per Ha	broad-leaf	grass
1.	Imazaquin	0.14	6.7	10.0
2.	Imazaquin	0.28	7.5	10.0
3.	Imazaquin	0.43	7.7	10.0
4.	Imazaquin + Metribuzin	0.071 + 0.28	7.8	10.0
5.	Imazethapyr	0.14	7.3	10.0
6.	Imazethapyr	0.28	9.0	10.0
7.	Imazethapyr	0.43	9.2	10.0
8.	Imazethapyr + Imazaquin	0.071 + 0.071	8.3	10.0
9.	Clomazone	1.1	4.0	10.0
10.	Clomazone	2.2	6.3	10.0
11.	Clomazone	3.4	7.5	10.0
12.	Clomazone + Imazaquin	0.84 + 0.071	7.8	10.0
13.	Clomazone + Metribuzin	0.84 + 0.28	7.6	10.0
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	7.0	9.9
15.	Cinmethylin	1.3	9.3	10.0
16.	Cinmethylin	2.7	8.7	10.0
17.	Cinmethylin	4.0	9.3	10.0
18.	Cinmethylin + Imazaquin	1.1 + 0.071	8.2	10.0
19.	Chlorimuron-ethyl	8.7 g	6.7	10.0
20.	Chlorimuron-ethyl	17.5 g	7.8	9.9
21.	Chlorimuron-ethyl	26.3 g	8.9	10.0
22.	DPX-L8347	0.42	9.1	10.0
23.	DPX-L8347	0.84	7.8	10.0
24.	Standard		7.7	10.0
	$LSD_{(.05)}$		1.2	NS
	CV %		11.4	0.5

Table 17: 1985 Manhattan puncturevine, pigweed, and carpetweed ratings.

No.	Herbicide Treatment	Kg A.I. per Ha	Puvi	Pwsp	Cawe
1.	Imazaquin	0.14	9.9	9.9	10.0
2.	Imazaquin	0.28	10.0	10.0	10.0
3.	Imazaquin	0.43	10.0	10.0	10.0
4.	Imazaquin + Metribuzin	0.071 + 0.28	9.6	10.0	10.0
5.	Imazethapyr	0.14	7.7	10.0	10.0
6.	Imazethapyr	0.28	9.9	10.0	10.0
7.	Imazethapyr	0.43	9.9	10.0	10.0
8.	Imazethapyr + Imazaquin	0.071 + 0.071	9.9	9.9	10.0
9.	Clomazone	1.1	0.3	4.3	4.3
10.	Clomazone	2.2	7.2	9.2	6.3
11.	Clomazone	3.4	9.8	9.8	7.3
12.	Clomazone + Imazaquin	0.84 + 0.071	9.9	10.0	10.0
13.	Clomazone + Metribuzin	0.84 + 0.28	7.2	9.2	10.0
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	7.0	9.3	10.0
15.	Cinmethylin	1.3	7.4	9.7	10.0
16.	Cinmethylin	2.7	8.3	9.7	10.0
17.	Cinmethylin	4.0	9.7	10.0	10.0
18.	Cinmethylin + Imazaquin	1.1 + 0.071	10.0	10.0	10.0
19.	Chlorimuron-ethyl	8.7 g	5.0	10.0	10.0
20.	Chlorimuron-ethyl	17.5 g	9.1	10.0	10.0
21.	Chlorimuron-ethyl	26.3 g	9.6	10.0	10.0
22.	DPX-L8347	0.42	9.5	10.0	10.0
23.	DPX-L8347	0.84	6.8	10.0	10.0
24.	Standard		7.8	10.0	10.0
	$LSD_{(.05)}$		2.3	0.7	0.9
	CV %		20.2	5.0	6.8

Table 18: 1985 Manhattan smooth ground cherry and honeyvine milkweed ratings.

No.	Herbicide Treatment	Kg A.I. per Ha	Smgc (7/3)	Smgc (10/14)	Hvmw
1.	Imazaquin	0.14	5.7	5.7	8.7
2.	Imazaquin	0.28	6.2	6.8	9.7
3.	Imazaquin	0.43	6.5	7.0	9.6
4.	Imazaquin + Metribuzin	0.071 + 0.28	7.2	7.2	8.9
5.	Imazethapyr	0.14	8.0	7.0	7.7
6.	Imazethapyr	0.28	9.2	9.2	8.3
7.	Imazethapyr	0.43	9.2	8.8	9.4
8.	Imazethapyr + Imazaquin	0.071 + 0.071	8.3	7.3	8.8
9.	Clomazone	1.1	6.0	6.0	9.8
10.	Clomazone	2.2	6.5	5.8	9.9
11.	Clomazone	3.4	7.2	6.7	9.6
12.	Clomazone + Imazaquin	0.84 + 0.071	7.7	7.5	8.8
13.	Clomazone + Metribuzin	0.84 + 0.28	7.8	7.3	9.4
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	7.2	7.3	9.2
15.	Cinmethylin	1.3	9.8	8.5	9.7
16.	Cinmethylin	2.7	8.9	8.8	9.6
17.	Cinmethylin	4.0	9.1	8.2	9.6
18.	Cinmethylin + Imazaquin	1.1 + 0.071	7.3	7.3	9.2
19.	Chlorimuron-ethyl	8.7 g	6.8	6.5	9.8
20.	Chlorimuron-ethyl	17.5 g	8.2	8.2	8.5
21.	Chlorimuron-ethyl	26.3 g	8.5	8.2	9.8
22.	DPX-L8347	0.42	9.2	8.5	9.3
23.	DPX-L8347	0.84	7.8	8.2	9.8
24.	Standard		7.7	6.2	9.9
	$LSD_{(.05)}$		1.4	1.2	NS
	CV %		12.9	12.2	8.7

Table 19: 1986 Manhattan overall broadleaf, Eastern black nightshade, smooth ground cherry, and morningglory sp.

No.	Herbicide Treatment	Kg A.I. per Ha	broad-leaf	Smgc	Ebns	Mgsp
1.	Imazaquin	0.14	8.7	3.7	9.7	10.0
2.	Imazaquin	0.28	8.9	7.0	9.9	9.9
3.	Imazaquin	0.43	8.7	2.3	10.0	10.0
4.	Imazaquin + Metribuzin	0.071 + 0.28	8.3	2.3	10.0	9.7
5.	Imazethapyr	0.14	8.7	0.7	9.9	10.0
6.	Imazethapyr	0.28	8.2	0.0	10.0	10.0
7.	Imazethapyr	0.43	9.5	0.3	10.0	10.0
8.	Imazethapyr + Imazaquin	0.071 + 0.071	8.8	1.0	10.0	9.9
9.	Clomazone	1.1	6.8	4.7	9.3	10.0
10.	Clomazone	2.2	7.4	7.3	8.7	10.0
11.	Clomazone	3.4	7.7	8.3	9.3	10.0
12.	Clomazone + Imazaquin	0.84 + 0.071	8.3	1.7	9.9	10.0
13.	Clomazone + Metribuzin	0.84 + 0.28	8.3	6.3	9.7	10.0
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	7.8	3.0	9.9	9.9
15.	Cinmethylin	1.3	8.6	2.3	9.8	10.0
16.	Cinmethylin	2.7	8.9	1.0	10.0	10.0
17.	Cinmethylin	4.0	8.7	1.0	9.7	10.0
18.	Cinmethylin + Imazaquin	1.1 + 0.071	7.7	6.0	9.3	9.0
19.	Chlorimuron-ethyl	8.7 g	6.5	5.3	10.0	9.3
20.	Chlorimuron-ethyl	17.5 g	7.9	5.3	9.9	9.9
21.	Chlorimuron-ethyl	26.3 g	8.3	1.7	10.0	10.0
22.	DPX-L8347	0.42	8.9	3.0	9.8	9.9
23.	DPX-L8347	0.84	9.2	2.0	10.0	10.0
24.	Standard		7.8	1.7	9.7	10.0
	$LSD_{(.05)}$		1.1	NS	0.4	NS
	CV %		9.4	122.9	3.0	4.4

Table 20: 1986 Manhattan carpetweed, pigweed, and puncturevine ratings.

No.	Herbicide Treatment	Kg A.I. per Ha	Cawe	Puvi	Pwsp
1.	Imazaquin	0.14	10.0	8.0	9.7
2.	Imazaquin	0.28	9.8	9.0	10.0
3.	Imazaquin	0.43	9.8	9.6	10.0
4.	Imazaquin + Metribuzin	0.071 + 0.28	10.0	8.2	9.6
5.	Imazethapyr	0.14	9.9	8.8	10.0
6.	Imazethapyr	0.28	10.0	8.1	9.8
7.	Imazethapyr	0.43	9.9	9.6	10.0
8.	Imazethapyr + Imazaquin	0.071 + 0.071	10.0	8.7	9.8
9.	Clomazone	1.1	7.3	7.5	7.8
10.	Clomazone	2.2	7.3	7.6	9.3
11.	Clomazone	3.4	7.8	8.8	9.8
12.	Clomazone + Imazaquin	0.84 + 0.071	10.0	8.4	9.2
13.	Clomazone + Metribuzin	0.84 + 0.28	10.0	8.8	10.0
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	9.5	6.5	9.8
15.	Cinmethylin	1.3	9.9	8.5	9.7
16.	Cinmethylin	2.7	10.0	8.8	9.9
17.	Cinmethylin	4.0	9.9	8.2	9.7
18.	Cinmethylin + Imazaquin	1.1 + 0.071	9.3	8.7	9.2
19.	Chlorimuron-ethyl	8.7 g	9.8	5.7	9.7
20.	Chlorimuron-ethyl	17.5 g	10.0	8.0	10.0
21.	Chlorimuron-ethyl	26.3 g	9.8	7.7	10.0
22.	DPX-L8347	0.42	10.0	9.0	10.0
23.	DPX-L8347	0.84	10.0	9.7	10.0
24.	Standard		10.0	6.8	9.8
	$LSD_{(.05)}$		0.7	1.4	0.4
	CV %		5.1	12.6	3.4

Visual observations show that imazaquin and imazethapyr both have activity on puncturevine. Puncturevine emerged, turned brown, and soon died. In 1985, most rates of both herbicides gave near complete control of puncturevine. However, in 1986, control was variable with these herbicides. Even though control was variable, this is a promising finding, since no registered soybean herbicide PRE will control puncturevine. The imazaquin label lists puncturevine as a weed controlled with soil-applied treatments.

Imazaquin and imazethapyr also have some activity on smooth ground cherry, a perennial. This control was observed in 1985 and is reflected by both ratings in 1985, but not in 1986. Although stunting was the dominant characteristic of the herbicide activity, limited control of the weed was observed and was reflected by increasing control with increasing herbicide rates. This is interesting, since no current soybean herbicide PRE will control smooth ground cherry. However, the imazaquin label does not mention any control or suppression of this weed.

<u>Rossville</u>

Weed population at the Rossville site was heavy both years. In 1985, only overall broadleaf and grass ratings were taken. Broadleaf weeds in the plot were primarily pigweed sp. Grassy weed population was predominatly

crabgrass sp. (Table 21). In 1986, ratings were taken for pigweed sp., crabgrass sp., and common sunflower (*Helianthus annuus* L.) (Table 22). The ratings for pigweed and crabgrass were statistically significant both years. Sunflower population was heavy, but no statistical differences between treatments existed. Sunflowers were killed with glyphosate solution in a rope-wick applicator.

Close examination of the pigweed ratings shows that in 1985 clomazone did not adequately control this weed as did the other treatments. Results of the 1986 pigweed ratings show that clomazone gave very poor control (0 - 2.0). Lower rates of imazaquin (0.071 kg/ha and 0.14 kg/ha) and chlorimuron-ethyl + alachlor treatments also resulted in significantly lower pigweed control compared to other treatments, even though both imazaquin and alachlor are labeled to control pigweed(1, 23).

Crabgrass ratings in 1985 show that imazaquin gave reduced grass control compared to the other treatments. The 1986 results showed that cinmethylin and chlorimuron-ethyl + alachlor treatments did not give adequate crabgrass control. However, cinmethylin was reported to give good crabgrass control by Price and May(26).

Table 21: 1985 Rossville overall broadleaf and grass ratings.

No.	Herbicide Treatment	Kg A.I. per Ha	broad-leaf	grass
1.	Imazaquin	0.14	10.0	8.2
2.	Imazaquin	0.28	10.0	9.0
3.	Imazaquin	0.43	10.0	9.8
4.	Imazaquin + Metribuzin	0.071 + 0.28	10.0	9.2
5.	Imazethapyr	0.14	10.0	10.0
6.	Imazethapyr	0.28	10.0	10.0
7.	Imazethapyr	0.43	10.0	10.0
8.	Imazethapyr + Imazaquin	0.071 + 0.071	10.0	10.0
9.	Clomazone	1.1	8.5	10.0
10.	Clomazone	2.2	8.5	10.0
11.	Clomazone	3.4	9.0	10.0
12.	Clomazone + Imazaquin	0.84 + 0.071	10.0	10.0
13.	Clomazone + Metribuzin	0.84 + 0.28	8.8	10.0
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	9.8	9.8
15.	Cinmethylin	1.3	7.7	10.0
16.	Cinmethylin	2.7	7.0	9.7
17.	Cinmethylin	4.0	9.5	10.0
18.	Cinmethylin + Imazaquin	1.1 + 0.071	10.0	10.0
19.	Chlorimuron-ethyl	8.7 g	10.0	10.0
20.	Chlorimuron-ethyl	17.5 g	10.0	10.0
21.	Chlorimuron-ethyl	26.3 g	10.0	9.8
22.	DPX-L8347	0.42	10.0	10.0
23.	DPX-L8347	0.84	10.0	10.0
24.	Standard		10.0	10.0
	$LSD_{(.05)}$		1.6	0.5
	CV %		10.0	4.3

Table 22: 1986 Rossville crabgrass, pigweed and sunflower control ratings.

No.	Herbicide Treatment	Kg A.I. per Ha	Cgsp	Pgsp	Cosf
1.	Imazaquin	0.14	7.7	5.5	10.0
2.	Imazaquin	0.28	8.5	7.8	10.0
3.	Imazaquin	0.43	8.0	9.0	10.0
4.	Imazaquin + Metribuzin	0.071 + 0.28	7.5	6.2	9.8
5.	Imazethapyr	0.14	8.2	8.0	9.7
6.	Imazethapyr	0.28	8.7	8.8	10.0
7.	Imazethapyr	0.43	9.2	9.0	10.0
8.	Imazethapyr + Imazaquin	0.071 + 0.071	9.2	8.2	10.0
9.	Clomazone	1.1	9.0	0.0	9.3
10.	Clomazone	2.2	8.8	6.7	8.0
11.	Clomazone	3.4	9.3	2.0	8.3
12.	Clomazone + Imazaquin	0.84 + 0.071	8.3	7.0	10.0
13.	Clomazone + Metribuzin	0.84 + 0.28	9.5	6.7	9.3
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	8.8	2.0	9.3
15.	Cinmethylin	1.3	6.3	10.0	9.3
16.	Cinmethylin	2.7	6.7	10.0	9.3
17.	Cinmethylin	4.0	6.7	9.8	9.7
18.	Cinmethylin + Imazaquin	1.1 + 0.071	5.7	7.5	10.0
19.	Chlorimuron-ethyl	8.7 g	5.0	5.3	9.3
20.	Chlorimuron-ethyl	17.5 g	5.2	6.2	9.0
21.	Chlorimuron-ethyl	26.3 g	6.8	6.5	8.7
22.	DPX-L8347	0.42	8.0	7.5	9.3
23.	DPX-L8347	0.84	8.5	8.5	9.5
24.	Standard		5.0	8.0	10.0
	$LSD_{(.05)}$		2.8	23.2	NS
	CV %		22.2	21.1	7.7

Some of the reduced weed control seen at the Rossville site can be attributed to the sandy soils. However, the poor pigweed control seen here with clomazone is supported by similar results at other locations.

Ottawa

The Ottawa site had light weed populations both years. Weed species rated in 1985 include morningglory sp., pigweed sp., venice mallow, prickly sida, velvetleaf, crabgrass sp., yellow foxtail, and fall panicum (Tables 23 and 24). Also, overall broadleaf and grass ratings were taken in 1985 (Table 25). In 1986, broadleaf weeds, fall panicum, morningglory sp., and velvetleaf control were rated (Table 26). Results from 1985 indicate a statistically significant difference in overall broadleaf and grass control, venice mallow, prickly sida, and velvetleaf control. However, no differences in 1986 ratings could be statistically demonstrated.

The differences in 1985 between treatments to control venice mallow, prickly sida, and velvetleaf can all be attributed to reduced control of these weeds by chlorimuron-ethyl. All other treatments provided good control. However, this is not of great importance since chlorimuron-ethyl alone is used PE rather than PRE as in this experiment. The other significant difference in 1985 is shown by the reduced grass control (primarily fall

Table 23: 1985 Ottawa venice mallow, prickly sida, and velvetleaf ratings.

No.	Herbicide Treatment	Kg A.I. per Ha	Vema	Prsi	Vele
1.	Imazaquin	0.14	9.7	9.3	9.3
2.	Imazaquin	0.28	9.8	9.0	9.7
3.	Imazaquin	0.43	10.0	9.3	10.0
4.	Imazaquin + Metribuzin	0.071 + 0.28	9.7	9.2	9.7
5.	Imazethapyr	0.14	10.0	9.5	9.7
6.	Imazethapyr	0.28	10.0	9.8	9.8
7.	Imazethapyr	0.43	10.0	9.7	10.0
8.	Imazethapyr + Imazaquin	0.071 + 0.071	9.7	9.0	9.7
9.	Clomazone	1.1	10.0	9.7	9.7
10.	Clomazone	2.2	9.8	8.7	9.8
11.	Clomazone	3.4	9.8	8.8	10.0
12.	Clomazone + Imazaquin	0.84 + 0.071	9.5	9.7	10.0
13.	Clomazone + Metribuzin	0.84 + 0.28	9.3	9.0	9.7
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	9.7	8.9	10.0
15.	Cinmethylin	1.3	9.0	7.3	9.9
16.	Cinmethylin	2.7	8.8	7.7	9.8
17.	Cinmethylin	4.0	8.7	7.8	9.9
18.	Cinmethylin + Imazaquin	1.1 + 0.071	9.0	8.0	9.3
19.	Chlorimuron-ethyl	8.7 g	7.3	6.3	8.3
20.	Chlorimuron-ethyl	17.5 g	6.0	5.2	10.0
21.	Chlorimuron-ethyl	26.3 g	7.0	6.0	10.0
22.	DPX-L8347	0.42	9.0	8.2	10.0
23.	DPX-L8347	0.84	9.1	8.0	9.7
24.	Standard		9.0	7.8	10.0
	$LSD_{(.05)}$		1.4	1.4	0.6
	CV %		11.4	12.4	4.7

Table 24: 1985 Ottawa pigweed, morningglory, crabgrass, and fall panicum ratings.

No.	Herbicide Treatment	Kg A.I. per Ha	Pwsp	Mgsp	Cgsp	Fapa
1.	Imazaquin	0.14	10.0	6.3	9.5	8.3
2.	Imazaquin	0.28	10.0	7.7	9.7	9.5
3.	Imazaquin	0.43	10.0	9.0	10.0	9.9
4.	Imazaquin + Metribuzin	0.071 + 0.28	9.8	8.8	10.0	9.9
5.	Imazethapyr	0.14	10.0	8.8	10.0	9.8
6.	Imazethapyr	0.28	10.0	9.3	10.0	9.9
7.	Imazethapyr	0.43	10.0	9.0	10.0	10.0
8.	Imazethapyr + Imazaquin	0.071 + 0.071	10.0	9.0	9.5	9.8
9.	Clomazone	1.1	10.0	8.3	10.0	10.0
10.	Clomazone	2.2	9.8	8.5	10.0	10.0
11.	Clomazone	3.4	10.0	9.3	10.0	10.0
12.	Clomazone + Imazaquin	0.84 + 0.071	10.0	7.8	10.0	10.0
13.	Clomazone + Metribuzin	0.84 + 0.28	9.8	8.5	10.0	10.0
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	9.7	9.0	9.8	9.7
15.	Cinmethylin	1.3	9.8	8.8	10.0	10.0
16.	Cinmethylin	2.7	10.0	8.7	10.0	9.6
17.	Cinmethylin	4.0	10.0	9.5	10.0	10.0
18.	Cinmethylin + Imazaquin	1.1 + 0.071	10.0	8.7	10.0	7.0
19.	Chlorimuron-ethyl	8.7 g	10.0	8.5	9.7	10.0
20.	Chlorimuron-ethyl	17.5 g	10.0	9.2	9.7	9.8
21.	Chlorimuron-ethyl	26.3 g	10.0	8.2	10.0	9.3
22.	DPX-L8347	0.42	10.0	8.3	10.0	10.0
23.	DPX-L8347	0.84	9.8	8.8	9.5	9.8
24.	Standard		10.0	9.7	10.0	10.0
	LSD(.05)		NS	NS	NS	NS
	CV %		1.5	11.6	2.9	10.7

Table 25: 1985 Ottawa overall broadleaf and grass ratings.

No.	Herbicide Treatment	Kg A.I. per Ha	broad-leaf	grass
1.	Imazaquin	0.14	6.7	8.5
2.	Imazaquin	0.28	7.8	9.4
3.	Imazaquin	0.43	9.1	9.9
4.	Imazaquin + Metribuzin	0.071 + 0.28	8.9	9.8
5.	Imazethapyr	0.14	9.0	9.8
6.	Imazethapyr	0.28	9.5	9.9
7.	Imazethapyr	0.43	9.2	10.0
8.	Imazethapyr + Imazaquin	0.071 + 0.071	9.7	9.7
9.	Clomazone	1.1	8.3	10.0
10.	Clomazone	2.2	8.2	10.0
11.	Clomazone	3.4	9.5	10.0
12.	Clomazone + Imazaquin	0.84 + 0.071	8.8	10.0
13.	Clomazone + Metribuzin	0.84 + 0.28	9.1	10.0
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	8.6	9.7
15.	Cinmethylin	1.3	8.0	10.0
16.	Cinmethylin	2.7	8.0	9.6
17.	Cinmethylin	4.0	8.4	10.0
18.	Cinmethylin + Imazaquin	1.1 + 0.071	8.2	9.8
19.	Chlorimuron-ethyl	8.7 g	7.0	9.7
20.	Chlorimuron-ethyl	17.5 g	5.8	9.5
21.	Chlorimuron-ethyl	26.3 g	6.5	9.3
22.	DPX-L8347	0.42	8.2	10.0
23.	DPX-L8347	0.84	8.3	9.8
24.	Standard		8.7	10.0
	$LSD_{(.05)}$		1.3	0.5
	CV %		11.1	3.7

Table 26: 1986 Ottawa overall broadleaf, fall panicum, morningglory and velvetleaf ratings.

No.	Herbicide Treatment	Kg A.I. per Ha	broad-leaf	Fapa	Mgsp	Vele
1.	Imazaquin	0.14	8.9	8.4	8.9	9.8
2.	Imazaquin	0.28	9.4	9.1	9.4	10.0
3.	Imazaquin	0.43	9.4	9.7	9.4	10.0
4.	Imazaquin + Metribuzin	0.071 + 0.28	8.6	8.8	8.6	10.0
5.	Imazethapyr	0.14	8.1	9.8	8.1	10.0
6.	Imazethapyr	0.28	9.4	10.0	9.4	10.0
7.	Imazethapyr	0.43	9.5	10.0	9.5	10.0
8.	Imazethapyr + Imazaquin	0.071 + 0.071	8.9	9.7	8.9	10.0
9.	Clomazone	1.1	8.7	9.9	8.7	10.0
10.	Clomazone	2.2	9.7	10.0	9.7	10.0
11.	Clomazone	3.4	9.8	9.9	9.8	10.0
12.	Clomazone + Imazaquin	0.84 + 0.071	9.2	9.8	9.2	10.0
13.	Clomazone + Metribuzin	0.84 + 0.28	9.3	9.9	9.3	10.0
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	8.3	9.5	8.3	9.9
15.	Cinmethylin	1.3	9.5	9.7	9.5	9.9
16.	Cinmethylin	2.7	9.6	9.8	9.7	9.9
17.	Cinmethylin	4.0	9.8	9.9	9.8	10.0
18.	Cinmethylin + Imazaquin	1.1 + 0.071	8.8	9.4	8.8	9.9
19.	Chlorimuron-ethyl	8.7 g	8.3	9.2	8.5	9.5
20.	Chlorimuron-ethyl	17.5 g	8.2	9.8	8.2	10.0
21.	Chlorimuron-ethyl	26.3 g	9.2	9.8	9.2	10.0
22.	DPX-L8347	0.42	9.4	9.9	9.4	10.0
23.	DPX-L8347	0.84	9.4	9.9	9.4	10.0
24.	Standard		9.2	9.5	9.5	10.0
	$LSD_{(.05)}$		NS	NS	NS	NS
	CV %		8.5	6.0	8.5	1.8

panicum) given by the 0.14 kg/ha rate of imazaquin. Here again, a greater weed population was needed to test the weed control efficacy of these herbicides.

A problem characteristic of clomazone showed up in the 1985 plot. This characteristic was discussed in the literature review. White velvetleaf appeared in plots not treated with clomazone, indicating off-target movement. Halstead and Harvey(19) found the likelihood of this movement to increase with wet soil surfaces. The day of herbicide application at Ottawa, 2.4 cm of rain fell. This rainfall could explain why the Ottawa 1985 plot was the only site where this movement was observed. Movement was not significant enough to greatly affect weed control ratings.

Hesston

Weed pressure was virtually non-existent both years at Hesston; so no ratings were taken.

Summary of Weed Control

Conclusions that can be drawn from the weed control section are limited since weed pressure was light and weed control efficacy was not the primary emphasis of this project. However, we can conclude that clomazone does not provide adequate pigweed and carpetweed control, but other herbicides that can be tankmixed with clomazone control these weeds easily. Also imazethapyr gives improved grass control as shown by crabgrass and fall panicum in this

study compared to imazaquin, even though the chemistry of these compounds is so similiar.

CROP SAFETY

Only herbicide treatments that showed injury to the soybeans will be discussed.

Manhattan

Cinmethylin caused injury to soybeans at all rates in both 1985 and 1986. Delayed germination, wrinkled leaves, and stunted plants were symptoms of the injury. Stunting persisted throughout the season as shown by height measurements in 1985 (Table 27). However, soybean yields were not affected (Table 28). In 1986, the 3X rates of imazaquin and imazethapyr also caused slight stunting early in the season (Table 29). Later in the season no visual height difference from this injury could be detected. Yield was not affected by either imazaquin or imazethapyr.

Rossville

The high sand content and low organic matter content of the soils are important to remember when looking at the crop safety results of the Rossville site. Considerable injury was observed in 1985 with all treatments except low rates of imazaquin and clomazone. Cinmethylin again caused season-long stunting. This injury caused significant yield

Table 27: 1985 Manhattan soybean crop injury ratings and crop height measurements.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Crop height (cm)
1.	Imazaquin	0.14	0.0	114.8
2.	Imazaquin	0.28	0.0	113.0
3.	Imazaquin	0.43	0.0	113.3
4.	Imazaquin + Metribuzin	0.071 + 0.28	0.0	113.0
5.	Imazethapyr	0.14	0.0	113.3
6.	Imazethapyr	0.28	0.0	111.3
7.	Imazethapyr	0.43	0.0	114.0
8.	Imazethapyr + Imazaquin	0.071 + 0.071	0.0	113.8
9.	Clomazone	1.1	0.0	108.5
10.	Clomazone	2.2	0.0	111.0
11.	Clomazone	3.4	0.0	111.3
12.	Clomazone + Imazaquin	0.84 + 0.071	0.0	111.8
13.	Clomazone + Metribuzin	0.84 + 0.28	0.0	111.0
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	0.0	111.8
15.	Cinmethylin	1.3	2.0	101.1
16.	Cinmethylin	2.7	3.0	100.3
17.	Cinmethylin	4.0	4.0	101.3
18.	Cinmethylin + Imazaquin	1.1 + 0.071	1.0	108.7
19.	Chlorimuron-ethyl	8.7 g	0.0	112.5
20.	Chlorimuron-ethyl	17.5 g	0.0	108.5
21.	Chlorimuron-ethyl	26.3 g	0.0	108.0
22.	DPX-L8347	0.42	0.0	111.0
23.	DPX-L8347	0.84	0.0	111.3
24.	Standard		0.0	111.3
	$LSD_{(.05)}$		0.0	3.8
	CV %		0.0	2.5

Table 28: 1985 Manhattan soybean grain moistures, grain test weights, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Moisture (%)	Test weight (kg/m^3)	Yield (kg/ha)
1.	Imazaquin	0.14	12.7	683	2071
2.	Imazaquin	0.28	12.7	684	2253
3.	Imazaquin	0.43	12.9	680	1991
4.	Imazaquin + Metribuzin	0.071 + 0.28	13.2	681	2287
5.	Imazethapyr	0.14	12.9	681	2065
6.	Imazethapyr	0.28	13.1	676	2058
7.	Imazethapyr	0.43	12.7	681	2112
8.	Imazethapyr + Imazaquin	0.071 + 0.071	13.1	681	2018
9.	Clomazone	1.1	12.9	686	2273
10.	Clomazone	2.2	12.9	680	2334
11.	Clomazone	3.4	13.3	677	2334
12.	Clomazone + Imazaquin	0.84 + 0.071	13.3	677	2226
13.	Clomazone + Metribuzin	0.84 + 0.28	13.4	681	2260
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	13.3	680	2441
15.	Cinmethylin	1.3	13.1	690	2515
16.	Cinmethylin	2.7	13.2	675	2219
17.	Cinmethylin	4.0	13.2	680	2347
18.	Cinmethylin + Imazaquin	1.1 + 0.071	13.4	680	2428
19.	Chlorimuron-ethyl	8.7 g	13.1	682	2219
20.	Chlorimuron-ethyl	17.5 g	13.4	681	2441
21.	Chlorimuron-ethyl	26.3 g	13.4	680	2139
22.	DPX-L8347	0.42	13.3	677	2186
23.	DPX-L8347	0.84	13.5	683	2354
24.	Standard		13.2	669	2152
	$LSD_{(.05)}$		NS	NS	NS
	CV %		2.7	1.2	9.6

Table 29: 1986 Manhattan soybeans crop injury ratings, grain moisture, grain test weight, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Moisture (%)	Test weight (kg/m^3)	Yield (kg/ha)
1.	Imazaquin	0.14	0.0	11.4	693	3579
2.	Imazaquin	0.28	0.0	11.2	695	3523
3.	Imazaquin	0.43	1.0	11.2	695	3598
4.	Imazaquin +	0.071	0.0	11.4	692	3349
	Metribuzin	0.28				
5.	Imazethapyr	0.14	0.0	11.3	693	3662
6.	Imazethapyr	0.28	0.0	11.2	698	3577
7.	Imazethapyr	0.43	1.2	11.3	698	3583
8.	Imazethapyr +	0.071	0.0	11.0	698	3418
	Imazaquin	0.071				
9.	Clomazone	1.1	0.0	11.4	690	3558
10.	Clomazone	2.2	0.0	11.1	695	3513
11.	Clomazone	3.4	0.0	11.2	694	3544
12.	Clomazone +	0.84	0.0	11.1	694	3579
	Imazaquin	0.071				
13.	Clomazone +	0.84	0.0	11.2	698	3512
	Metribuzin	0.28				
14.	Clomazone +	0.84	0.0	11.4	695	3637
	Chlorimuron-ethyl	8.7 g				
15.	Cinmethylin	1.3	1.2	11.0	697	3464
16.	Cinmethylin	2.7	1.8	10.9	694	3477
17.	Cinmethylin	4.0	2.5	11.0	695	3431
18.	Cinmethylin +	1.1	0.8	11.2	697	3644
	Imazaquin	0.071				
19.	Chlorimuron-ethyl	8.7 g	0.0	11.0	694	3474
20.	Chlorimuron-ethyl	17.5 g	0.0	11.0	691	3652
21.	Chlorimuron-ethyl	26.3 g	0.0	11.1	694	3692
22.	DPX-L8347	0.42	0.0	10.9	694	3599
23.	DPX-L8347	0.84	0.0	11.0	695	3762
24.	Standard		0.0	11.2	693	3521
	$LSD_{(.05)}$		0.3	NS	NS	NS
	CV %		62.2	2.5	0.4	4.3

reductions compared to treatment 1 as seen in Table 30. Imazethapyr at all rates caused season-long stunting; however, only the 2X and 3X rates resulted in a yield reduction. The 2X and 3X rates of imazaquin also caused season-long stunting but no yield reduction. From these results in 1985, imazethapyr appears to be slightly more phytotoxic to soybeans at equal rates. Clomazone at the 3X rate whitened soybean leaves early in season, but soybeans quickly grew out of this injury. Chlormuron-ethyl and the chlorimuron-ethyl in DPX-L8347 also stunted soybeans, but yields were not statistically reduced.

Although the 1986 site is mapped as a soil having a higher sand content than the 1985 site, visually both sites appear to have a high sand content. Injury on the 1986 site is considerably less than 1985. No yield reduction due to crop injury occurred with any treatment (Table 31). The statistically significant differences in yield in 1986 were caused by differences in weed control rather than crop injury. Cinmethylin caused some early season stunting but the plants grew out of the injury symptom by mid-season. We don't have an explanation of the drastic difference between 1985 and 1986 in the phytotoxicity of these herbicides.

Ottawa

In both years cinmethylin stunted and, in some plots, reduced the soybean stand at Ottawa in 1985. This was the

Table 30: 1985 Rossville soybean crop injury ratings, grain moisture, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Moisture (%)	Yield (kg/ha)
1.	Imazaquin	0.14	0.0	12.2	3611
2.	Imazaquin	0.28	0.7	12.1	3221
3.	Imazaquin	0.43	0.7	12.0	3114
4.	Imazaquin + Metribuzin	0.071 + 0.28	0.0	12.1	3127
5.	Imazethapyr	0.14	0.5	11.9	3134
6.	Imazethapyr	0.28	1.3	12.0	2777
7.	Imazethapyr	0.43	2.0	12.4	2690
8.	Imazethapyr + Imazaquin	0.071 + 0.071	0.5	12.1	3430
9.	Clomazone	1.1	0.0	12.5	2905
10.	Clomazone	2.2	0.0	12.8	3033
11.	Clomazone	3.4	1.3	12.7	2973
12.	Clomazone + Imazaquin	0.84 + 0.071	0.0	12.1	3221
13.	Clomazone + Metribuzin	0.84 + 0.28	0.0	12.6	2670
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	0.2	12.6	2777
15.	Cinmethylin	1.3	0.7	12.7	2770
16.	Cinmethylin	2.7	0.3	12.7	2717
17.	Cinmethylin	4.0	0.8	12.6	2825
18.	Cinmethylin + Imazaquin	1.1 + 0.071	0.0	12.5	3120
19.	Chlorimuron-ethyl	8.7 g	0.3	12.4	3147
20.	Chlorimuron-ethyl	17.5 g	0.5	12.2	2979
21.	Chlorimuron-ethyl	26.3 g	0.5	12.3	2999
22.	DPX-L8347	0.42	0.8	12.4	3134
23.	DPX-L8347	0.84	1.0	12.0	2872
24.	Standard		0.0	12.6	2757
	$LSD_{(.05)}$		0.6	0.7	404
	CV %		69.6	3.2	8.2

Table 31: 1986 Rossville soybean crop injury ratings, grain moisture, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Moisture (%)	Yield (kg/ha)
1.	Imazaquin	0.14	0.0	13.3	3268
2.	Imazaquin	0.28	0.0	13.3	4217
3.	Imazaquin	0.43	0.0	13.4	4071
4.	Imazaquin + Metribuzin	0.071 + 0.28	0.0	12.9	3934
5.	Imazethapyr	0.14	0.0	13.2	4279
6.	Imazethapyr	0.28	0.3	12.9	4490
7.	Imazethapyr	0.43	0.0	13.1	4116
8.	Imazethapyr + Imazaquin	0.071 + 0.071	0.0	12.8	4383
9.	Clomazone	1.1	0.0	13.5	2591
10.	Clomazone	2.2	0.0	13.7	2659
11.	Clomazone	3.4	0.0	13.4	3046
12.	Clomazone + Imazaquin	0.84 + 0.071	0.0	13.2	4147
13.	Clomazone + Metribuzin	0.84 + 0.28	0.0	13.3	3242
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	0.0	13.3	1991
15.	Cinmethylin	1.3	1.0	12.9	4235
16.	Cinmethylin	2.7	1.0	13.0	4044
17.	Cinmethylin	4.0	1.0	13.1	4335
18.	Cinmethylin + Imazaquin	1.1 + 0.071	0.0	13.3	3894
19.	Chlorimuron-ethyl	8.7 g	0.0	13.0	3111
20.	Chlorimuron-ethyl	17.5 g	0.0	13.2	3766
21.	Chlorimuron-ethyl	26.3 g	0.0	13.1	3629
22.	DPX-L8347	0.42	0.0	13.0	4015
23.	DPX-L8347	0.84	1.0	13.1	3493
24.	Standard		0.0	13.3	3445
	$LSD_{(.05)}$		0.4	NS	968
	CV %		130.5	2.6	16.0

only site where a stand loss from cinmethylin occurred. Stand loss has been observed in other research when rain occurred soon after treatment (14). Also, injury was observed by Price et al. (27) when cinmethylin was deeply incorporated. Since 2.5 cm rain fell the day of application, we will conclude that the additional phytotoxicity of cinmethylin was caused by rain incorporating the herbicide in the seed zone. Even though up to a 30% stand reduction occurred, yield was unaffected. Yields were unaffected both years. See Tables 32 and 33.

In 1986, chlorimuron-ethyl stunted soybeans slightly at several rates including both rates of DPX-L8347. The 2 X and 3 X rates of imazaquin and imazethapyr in 1986 also caused slight stunting.

<u>Hesston</u>

At Hesston no injury from any herbicide treatment was observed in 1985 (Table 34). But in 1986, cinmethylin stunted the soybeans at all rates. (Table 35) Statistically different yields in 1985 can not be attributed to any factor since there was no visible crop injury and few weeds were present in the plot. There was no statistical difference in yield in 1986. Cinmethylin caused injury at all locations both years except for 1985 at Hesston. The difference could be explained by the very dry conditions that followed soybean planting in June and early July.

Table 32: 1985 Ottawa soybean crop injury ratings and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Yield (kg/ha)
1.	Imazaquin	0.14	0.0	2381
2.	Imazaquin	0.28	0.0	2347
3.	Imazaquin	0.43	0.0	2273
4.	Imazaquin + Metribuzin	0.071 + 0.28	0.0	2293
5.	Imazethapyr	0.14	0.0	2347
6.	Imazethapyr	0.28	0.0	2340
7.	Imazethapyr	0.43	0.0	2219
8.	Imazethapyr + Imazaquin	0.071 + 0.071	0.0	2320
9.	Clomazone	1.1	0.0	2293
10.	Clomazone	2.2	0.0	2340
11.	Clomazone	3.4	0.0	2280
12.	Clomazone + Imazaquin	0.84 + 0.071	0.0	2354
13.	Clomazone + Metribuzin	0.84 + 0.28	0.0	2293
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	0.0	2260
15.	Cinmethylin	1.3	1.3	2287
16.	Cinmethylin	2.7	2.2	2145
17.	Cinmethylin	4.0	3.8	1991
18.	Cinmethylin + Imazaquin	1.1 + 0.071	0.7	2307
19.	Chlorimuron-ethyl	8.7 g	0.5	2387
20.	Chlorimuron-ethyl	17.5 g	0.0	2287
21.	Chlorimuron-ethyl	26.3 g	0.0	2334
22.	DPX-L8347	0.42	1.0	2226
23.	DPX-L8347	0.84	0.7	2313
24.	Standard		0.0	2361
	$LSD_{(.05)}$		0.9	NS
	CV %		150.3	6.0

Table 33: 1986 Ottawa soybean crop injury ratings, grain moisture, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Moisture (%)	Yield (kg/ha)
1.	Imazaquin	0.14	0.0	27.0	3228
2.	Imazaquin	0.28	0.3	26.7	3221
3.	Imazaquin	0.43	0.7	27.5	3255
4.	Imazaquin + Metribuzin	0.071 + 0.28	0.0	27.5	3330
5.	Imazethapyr	0.14	0.0	27.2	3402
6.	Imazethapyr	0.28	0.2	26.9	3260
7.	Imazethapyr	0.43	0.7	27.1	3225
8.	Imazethapyr + Imazaquin	0.071 + 0.071	0.2	27.1	3237
9.	Clomazone	1.1	0.0	27.6	3289
10.	Clomazone	2.2	0.0	27.2	3166
11.	Clomazone	3.4	0.0	27.7	3301
12.	Clomazone + Imazaquin	0.84 + 0.071	0.0	27.6	3234
13.	Clomazone + Metribuzin	0.84 + 0.28	0.0	27.3	3332
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	0.0	27.8	3104
15.	Cinmethylin	1.3	0.3	26.4	3523
16.	Cinmethylin	2.7	0.8	26.9	3229
17.	Cinmethylin	4.0	1.3	26.7	3352
18.	Cinmethylin + Imazaquin	1.1 + 0.071	0.2	27.3	3356
19.	Chlorimuron-ethyl	8.7 g	0.0	27.0	3306
20.	Chlorimuron-ethyl	17.5 g	0.0	26.5	3303
21.	Chlorimuron-ethyl	26.3 g	0.0	26.8	3421
22.	DPX-L8347	0.42	0.0	26.5	3152
23.	DPX-L8347	0.84	0.0	27.0	3184
24.	Standard		0.0	26.9	2976
	$LSD_{(.05)}$		0.3	NS	NS
	CV %		110.9	2.1	5.6

Table 34: 1985 Hesston soybean crop injury ratings, grain moisture, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Moisture (%)	Yield (kg/ha)
1.	Imazaquin	0.14	0.0	14.0	3611
2.	Imazaquin	0.28	0.0	13.6	3221
3.	Imazaquin	0.43	0.0	14.0	3114
4.	Imazaquin + Metribuzin	0.071 + 0.28	0.0	13.6	3127
5.	Imazethapyr	0.14	0.0	14.0	3134
6.	Imazethapyr	0.28	0.0	13.6	2777
7.	Imazethapyr	0.43	0.0	14.0	2690
8.	Imazethapyr + Imazaquin	0.071 + 0.071	0.0	13.7	3430
9.	Clomazone	1.1	0.0	13.8	2905
10.	Clomazone	2.2	0.0	13.7	3033
11.	Clomazone	3.4	0.0	13.5	2973
12.	Clomazone + Imazaquin	0.84 + 0.071	0.0	13.5	3221
13.	Clomazone + Metribuzin	0.84 + 0.28	0.0	13.6	2670
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	0.0	13.4	2777
15.	Cinmethylin	1.3	0.0	13.4	2770
16.	Cinmethylin	2.7	0.0	13.7	2717
17.	Cinmethylin	4.0	0.0	13.6	2824
18.	Cinmethylin + Imazaquin	1.1 + 0.071	0.0	13.3	3120
19.	Chlorimuron-ethyl	8.7 g	0.0	13.7	3147
20.	Chlorimuron-ethyl	17.5 g	0.0	13.5	2979
21.	Chlorimuron-ethyl	26.3 g	0.0	13.5	2999
22.	DPX-L8347	0.42	0.0	13.5	3134
23.	DPX-L8347	0.84	0.0	13.5	2872
24.	Standard		0.0	13.6	2757
	$LSD_{(.05)}$		NS	0.3	404
	CV %		0.0	1.5	7.5

Table 35: 1986 Hesston soybean crop injury ratings and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Yield (kg/ha)
1.	Imazaquin	0.14	0.0	3282
2.	Imazaquin	0.28	0.0	3430
3.	Imazaquin	0.43	0.0	3329
4.	Imazaquin + Metribuzin	0.071 + 0.28	0.0	3450
5.	Imazethapyr	0.14	0.0	3430
6.	Imazethapyr	0.28	0.0	3490
7.	Imazethapyr	0.43	0.0	3295
8.	Imazethapyr + Imazaquin	0.071 + 0.071	0.0	3403
9.	Clomazone	1.1	0.0	3416
10.	Clomazone	2.2	0.0	3578
11.	Clomazone	3.4	0.0	3598
12.	Clomazone + Imazaquin	0.84 + 0.071	0.0	3537
13.	Clomazone + Metribuzin	0.84 + 0.28	0.0	3490
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	0.0	3611
15.	Cinmethylin	1.3	0.4	3275
16.	Cinmethylin	2.7	0.8	3457
17.	Cinmethylin	4.0	1.3	3511
18.	Cinmethylin + Imazaquin	1.1 + 0.071	0.6	3591
19.	Chlorimuron-ethyl	8.7 g	0.0	3537
20.	Chlorimuron-ethyl	17.5 g	0.0	3544
21.	Chlorimuron-ethyl	26.3 g	0.0	3611
22.	DPX-L8347	0.42	0.0	3329
23.	DPX-L8347	0.84	0.0	3504
24.	Standard		0.0	3369
	$LSD_{(.05)}$		0.2	NS
	CV %		136.3	6.0

Summary of Crop Safety

Imazaquin and imazethapyr can cause some stunting at higher rates than normal and in light soils, but the margin of safety is well above acceptable. Nau et al.(24) and Sanborn et al.(31) report similar results. As clomazone was shown in this study to have an excellent margin of safey, the same was shown in other studies(5). Chlorimuron-ethyl, PRE, also has good crop tolerance but some injury can be expected. Gorrell et. al.(16) observed some injury with both PRE and PE applications. However, chlorimuron-ethyl alone is labeled for PE application rather than PRE as in this study. Cinmethylin injury was observed at the 1, 2, and 3 X rates in 7 of the 8 tests. In one of these tests a significant yield loss occurred. Similarly, this injury has been observed in other tests(27).

HERBICIDE PERSISTENCE

In this section, cinmethylin, chlorimuron-ethyl, and DPX-L8347 will not be discussed since no carry-over injury was observed with these herbicides.

MANHATTAN

Wheat: Year 1 (Tables 36-37)

At Manhattan several days after wheat began germinating in October 1985, wheat leaves in plots treated with 2X and

Table 36: 1986 Manhattan wheat crop injury ratings and crop height measurements.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Crop height (cm)
1.	Imazaquin	0.14	0.0	87.1
2.	Imazaquin	0.28	0.0	86.4
3.	Imazaquin	0.43	0.0	88.4
4.	Imazaquin + Metribuzin	0.071 + 0.28	0.0	84.6
5.	Imazethapyr	0.14	0.0	88.4
6.	Imazethapyr	0.28	0.8	85.1
7.	Imazethapyr	0.43	2.2	86.8
8.	Imazethapyr + Imazaquin	0.071 + 0.071	0.0	86.8
9.	Clomazone	1.1	0.0	90.2
10.	Clomazone	2.2	3.7	88.9
11.	Clomazone	3.4	5.8	87.1
12.	Clomazone + Imazaquin	0.84 + 0.071	0.0	88.1
13.	Clomazone + Metribuzin	0.84 + 0.28	0.0	88.9
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	0.0	88.9
15.	Cinmethylin	1.3	0.0	88.1
16.	Cinmethylin	2.7	0.0	84.3
17.	Cinmethylin	4.0	0.0	88.9
18.	Cinmethylin + Imazaquin	1.1 + 0.071	0.0	84.6
19.	Chlorimuron-ethyl	8.7 g	0.0	88.1
20.	Chlorimuron-ethyl	17.5 g	0.0	86.8
21.	Chlorimuron-ethyl	26.3 g	0.0	86.4
22.	DPX-L8347	0.42	0.0	84.3
23.	DPX-L8347	0.84	0.0	84.3
24.	Standard		0.0	88.1
	$LSD_{(.05)}$		0.7	NS
	CV %		104.1	2.9

Table 37: 1986 Manhattan wheat grain moistures, grain test weights, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Moisture (%)	Test weight (kg/m^3)	Yield (kg/ha)
1.	Imazaquin	0.14	11.6	680	2595
2.	Imazaquin	0.28	11.5	681	2624
3.	Imazaquin	0.43	11.7	683	2600
4.	Imazaquin + Metribuzin	0.071 + 0.28	11.3	688	2604
5.	Imazethapyr	0.14	11.6	678	2559
6.	Imazethapyr	0.28	11.4	677	2453
7.	Imazethapyr	0.43	11.5	670	2341
8.	Imazethapyr + Imazaquin	0.071 + 0.071	11.3	685	2694
9.	Clomazone	1.1	11.3	678	2695
10.	Clomazone	2.2	11.8	657	2388
11.	Clomazone	3.4	11.6	651	2029
12.	Clomazone + Imazaquin	0.84 + 0.071	11.1	690	2718
13.	Clomazone + Metribuzin	0.84 + 0.28	11.1	684	2507
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	11.2	679	2460
15.	Cinmethylin	1.3	11.3	694	2677
16.	Cinmethylin	2.7	11.2	694	2570
17.	Cinmethylin	4.0	11.5	684	2561
18.	Cinmethylin + Imazaquin	1.1 + 0.071	11.2	682	2669
19.	Chlorimuron-ethyl	8.7 g	11.4	684	2692
20.	Chlorimuron-ethyl	17.5 g	11.1	688	2709
21.	Chlorimuron-ethyl	26.3 g	11.3	673	2447
22.	DPX-L8347	0.42	11.1	673	2562
23.	DPX-L8347	0.84	11.1	680	2544
24.	Standard		11.3	687	2567
	$LSD_{(.05)}$		NS	NS	256
	CV %		2.1	2.0	7.3

3X rates of clomazone started turning white and slightly purple. Injured plants died over the winter causing stand reductions of up to 60%. Wheat leaves were white for a short time when wheat growth resumed in the spring, but soon turned green. No white leaves could be seen in plots treated with 1.12 kg/ha or 0.84 kg/ha. Relative amounts of stand reduction and leaf bleaching are indicated by crop injury ratings taken on 4/14/86. The wheat tillered heavily to compensate for the stand reduction in injured plots. The stand reduction could be seen throughout the growing season. The 3X rate of clomazone caused a slight yield reduction. Imazethapyr caused some slight stunting as indicated by crop injury ratings. This caused a yield reduction at the 3X rate. Grain test weight, grain moisture, and crop height were unaffected statistically by any herbicide carry-over injury.

Wheat: Year 2 (Tables 38-39)

The same results were evident with wheat planted at Manhattan in 1986 as with 1985. Stand reduction during winter was not as great as the previous year. Clomazone injury was greater in the wheel tracks where the combine had driven while harvesting soybeans. The soil was fairly wet and soft when soybeans were cut and the wheat was no-till drilled. However, there were no large "ruts," only slight wheel tracks. We are uncertain why the extra compaction in

Table 38: 1987 Manhattan wheat crop injury ratings and crop height measurements.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Crop height (cm)
1.	Imazaquin	0.14	0.0	75.9
2.	Imazaquin	0.28	0.0	80.0
3.	Imazaquin	0.43	0.0	76.5
4.	Imazaquin + Metribuzin	0.071 + 0.28	0.0	79.5
5.	Imazethapyr	0.14	0.0	79.2
6.	Imazethapyr	0.28	0.3	80.4
7.	Imazethapyr	0.43	0.5	77.7
8.	Imazethapyr + Imazaquin	0.071 + 0.071	0.0	80.2
9.	Clomazone	1.1	0.5	78.2
10.	Clomazone	2.2	3.3	80.0
11.	Clomazone	3.4	6.0	79.2
12.	Clomazone + Imazaquin	0.84 + 0.071	0.0	81.5
13.	Clomazone + Metribuzin	0.84 + 0.28	0.0	77.7
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	0.0	77.2
15.	Cinmethylin	1.3	0.0	76.5
16.	Cinmethylin	2.7	0.0	78.5
17.	Cinmethylin	4.0	0.0	81.5
18.	Cinmethylin + Imazaquin	1.1 + 0.071	0.0	78.7
19.	Chlorimuron-ethyl	8.7 g	0.0	81.3
20.	Chlorimuron-ethyl	17.5 g	0.0	80.4
21.	Chlorimuron-ethyl	26.3 g	0.0	78.7
22.	DPX-L8347	0.42	0.0	79.5
23.	DPX-L8347	0.84	0.0	79.8
24.	Standard		0.0	80.0
	$LSD_{(.05)}$		0.5	NS
	CV %		80.4	4.0

Table 39: 1987 Manhattan wheat grain moistures, grain test weights, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Moisture (%)	Test weight (kg/m^3)	Yield (kg/ha)
1.	Imazaquin	0.14	10.7	672	2732
2.	Imazaquin	0.28	10.7	673	3100
3.	Imazaquin	0.43	10.8	683	2858
4.	Imazaquin + Metribuzin	0.071 + 0.28	10.6	673	3084
5.	Imazethapyr	0.14	10.7	676	2786
6.	Imazethapyr	0.28	10.6	687	3029
7.	Imazethapyr	0.43	10.7	684	2750
8.	Imazethapyr + Imazaquin	0.071 + 0.071	10.8	675	2892
9.	Clomazone	1.1	10.7	680	2850
10.	Clomazone	2.2	10.7	681	2998
11.	Clomazone	3.4	10.7	683	2638
12.	Clomazone + Imazaquin	0.84 + 0.071	10.8	682	2911
13.	Clomazone + Metribuzin	0.84 + 0.28	10.7	676	2998
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	10.8	684	2840
15.	Cinmethylin	1.3	10.8	683	2822
16.	Cinmethylin	2.7	10.7	678	2867
17.	Cinmethylin	4.0	10.8	676	3117
18.	Cinmethylin + Imazaquin	1.1 + 0.071	10.9	683	2920
19.	Chlorimuron-ethyl	8.7 g	10.7	672	3148
20.	Chlorimuron-ethyl	17.5 g	10.7	683	3064
21.	Chlorimuron-ethyl	26.3 g	10.9	685	2919
22.	DPX-L8347	0.42	10.8	679	2875
23.	DPX-L8347	0.84	10.7	684	3164
24.	Standard		10.7	677	3100
	$LSD_{(.05)}$		NS	NS	NS
	CV %		1.2	1.3	9.2

the wheel tracks caused greater clomazone injury to the wheat. Imazethapyr caused similar stunting as it had the previous year. However, injury from clomazone and imazethapyr did not cause any yield reduction or difference in wheat height, grain moisture, or grain test weight.

Grain Sorghum: Year 1 (Tables 40-41)

Soon after the sorghum plants started emerging, leaves turned partially white in plots treated with clomazone at 1, 2, and 3X rates. Leaves soon turned green again and resumed normal growth, and yield was unaffected.

At the 9 July rating date, sorghum in imazethapyr plots was stunted and showed interveinal chlorosis. This injury persisted throughout the season and was quite severe at the 2 and 3X rates. The sorghum, with a high rate of imazaquin, was also stunted, but by late season the injury had disappeared. Yields were drastically reduced, maturity was delayed, grain moisture increased, and grain test weight was reduced with the 2 and 3X rates and, to a limited extent, with the lower rates of imazethapyr.

Grain Sorghum: Year 2 (Table 42)

Imazethapyr injury was slightly less severe in 1987 than in 1986. Similar injury was noted with clomazone as with the previous year. Yields were exceptionally high for double-cropped grain sorghum.

Table 40: 1986 Manhattan grain sorghum crop injury ratings and crop height measurements.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Crop height (cm)
1.	Imazaquin	0.14	0.0	132.1
2.	Imazaquin	0.28	0.0	131.6
3.	Imazaquin	0.43	1.0	127.6
4.	Imazaquin + Metribuzin	0.071 + 0.28	0.0	130.8
5.	Imazethapyr	0.14	2.7	124.2
6.	Imazethapyr	0.28	5.7	119.9
7.	Imazethapyr	0.43	6.7	118.4
8.	Imazethapyr + Imazaquin	0.071 + 0.071	2.2	123.4
9.	Clomazone	1.1	0.2	128.8
10.	Clomazone	2.2	1.0	130.0
11.	Clomazone	3.4	3.0	132.3
12.	Clomazone + Imazaquin	0.84 + 0.071	0.0	128.5
13.	Clomazone + Metribuzin	0.84 + 0.28	0.0	132.8
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	0.0	130.2
15.	Cinmethylin	1.3	0.0	131.6
16.	Cinmethylin	2.7	0.0	128.9
17.	Cinmethylin	4.0	0.0	130.8
18.	Cinmethylin + Imazaquin	1.1 + 0.071	0.0	129.8
19.	Chlorimuron-ethyl	8.7 g	0.0	130.4
20.	Chlorimuron-ethyl	17.5 g	0.0	130.4
21.	Chlorimuron-ethyl	26.3 g	0.0	130.0
22.	DPX-L8347	0.42	0.0	130.4
23.	DPX-L8347	0.84	0.0	132.9
24.	Standard		0.0	132.6
	$LSD_{(.05)}$		0.7	4.3
	CV %		52.2	2.5

Table 41: 1986 Manhattan grain sorghum grain moistures, grain test weights, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Moisture (%)	Test weight (kg/m^3)	Yield (kg/ha)
1.	Imazaquin	0.14	15.4	657	5820
2.	Imazaquin	0.28	15.9	655	5411
3.	Imazaquin	0.43	16.3	640	5420
4.	Imazaquin + Metribuzin	0.071 + 0.28	15.6	666	5464
5.	Imazethapyr	0.14	18.3	622	5296
6.	Imazethapyr	0.28	26.0	568	2404
7.	Imazethapyr	0.43	25.7	573	2217
8.	Imazethapyr + Imazaquin	0.071 + 0.071	18.6	628	5138
9.	Clomazone	1.1	16.0	640	5759
10.	Clomazone	2.2	16.2	651	5962
11.	Clomazone	3.4	15.9	640	6096
12.	Clomazone + Imazaquin	0.84 + 0.071	15.4	645	5737
13.	Clomazone + Metribuzin	0.84 + 0.28	15.4	662	6040
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	15.8	640	5656
15.	Cinmethylin	1.3	15.7	649	5761
16.	Cinmethylin	2.7	16.1	638	5433
17.	Cinmethylin	4.0	16.5	638	5457
18.	Cinmethylin + Imazaquin	1.1 + 0.071	15.9	646	5444
19.	Chlorimuron-ethyl	8.7 g	16.0	653	5657
20.	Chlorimuron-ethyl	17.5 g	15.3	636	5442
21.	Chlorimuron-ethyl	26.3 g	16.3	620	5462
22.	DPX-L8347	0.42	15.7	638	5585
23.	DPX-L8347	0.84	15.5	652	5534
24.	Standard		15.8	644	5681
	$LSD_{(.05)}$		1.5	23	615
	CV %		6.4	2.6	8.5

Table 42: 1987 Manhattan grain sorghum crop injury ratings, grain moisture, grain test weight, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Moisture (%)	Test weight (kg/m^3)	Yield (kg/ha)
1.	Imazaquin	0.14	0.0	25.2	624	7967
2.	Imazaquin	0.28	0.0	25.5	626	8087
3.	Imazaquin	0.43	0.2	25.6	613	7998
4.	Imazaquin +	0.071	0.0	25.3	618	8012
	Metribuzin	0.28				
5.	Imazethapyr	0.14	0.3	25.3	633	7516
6.	Imazethapyr	0.28	2.7	26.5	609	6404
7.	Imazethapyr	0.43	3.3	29.1	613	5165
8.	Imazethapyr +	0.071	0.0	25.6	634	7814
	Imazaquin	0.071				
9.	Clomazone	1.1	0.0	24.9	621	7648
10.	Clomazone	2.2	0.0	25.2	637	7950
11.	Clomazone	3.4	0.2	25.6	614	7916
12.	Clomazone +	0.84	0.0	25.1	627	8410
	Imazaquin	0.071				
13.	Clomazone +	0.84	0.0	25.0	626	8190
	Metribuzin	0.28				
14.	Clomazone +	0.84	0.0	25.3	613	7741
	Chlorimuron-ethyl	8.7 g				
15.	Cinmethylin	1.3	0.0	25.4	629	8163
16.	Cinmethylin	2.7	0.0	25.8	602	8205
17.	Cinmethylin	4.0	0.0	26.3	613	8275
18.	Cinmethylin +	1.1	0.0	24.8	629	8119
	Imazaquin	0.071				
19.	Chlorimuron-ethyl	8.7 g	0.0	25.4	620	7746
20.	Chlorimuron-ethyl	17.5 g	0.0	25.9	617	8026
21.	Chlorimuron-ethyl	26.3 g	0.0	25.2	622	7804
22.	DPX-L8347	0.42	0.0	25.1	642	7684
23.	DPX-L8347	0.84	0.0	25.4	619	7640
24.	Standard		0.0	26.0	627	7866
	$LSD_{(.05)}$		0.5	NS	NS	1116
	CV %		125.1	5.0	4.0	9.8

ROSSVILLE

Imazaquin will not be discussed since no carry-over injury was detected from this herbicide at the Rossville loaction.

Wheat: Year 1 (Table 43)

At Rossville injury to wheat from clomazone was similar to that in Manhattan, but considerably more severe. Up to a 90% stand reduction occurred. Because of the severe stand reduction in the 2 and 3X clomazone plots, weeds severely infested the plots, preventing harvest.

Imazethapyr did not cause any injury or yield loss to wheat at this location either year.

Wheat: Year 2 (Table 44)

Only very slight bleaching of wheat leaves due to clomazone was observed when crop injury ratings were taken on 3/11/87. The wheat grew out of this injury, and there was no stand loss or yield reduction. Grain moisture readings also did not differ statistically between any of the treatments. These sites are within 1 kilometer from each other. The most obvious difference between the sites is in pH. The pH for the Year 1 site is 6.0 and 7.4 for the Year 2 site. Even though the soil is mapped differently, a visual appraisal indicates that they both have a high sand content. More on differences in clomazone carry-over will

Table 43: 1986 Rossville wheat crop injury ratings, grain moisture, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Moisture (%)	Yield (kg/ha)
1.	Imazaquin	0.14	0.0	19.6	2374
2.	Imazaquin	0.28	0.0	19.4	2239
3.	Imazaquin	0.43	0.0	16.7	2172
4.	Imazaquin + Metribuzin	0.071 + 0.28	0.0	20.1	2354
5.	Imazethapyr	0.14	0.0	15.5	2556
6.	Imazethapyr	0.28	0.0	16.7	2428
7.	Imazethapyr	0.43	0.0	15.8	2401
8.	Imazethapyr + Imazaquin	0.071 + 0.071	0.0	17.5	2737
9.	Clomazone	1.1	0.0	20.1	2354
10.	Clomazone	2.2	3.0	-	834
11.	Clomazone	3.4	9.2	-	-
12.	Clomazone + Imazaquin	0.84 + 0.071	0.0	18.2	2771
13.	Clomazone + Metribuzin	0.84 + 0.28	0.0	19.8	2455
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	0.0	18.7	2663
15.	Cinmethylin	1.3	0.0	19.4	2616
16.	Cinmethylin	2.7	0.0	19.7	2475
17.	Cinmethylin	4.0	0.0	17.2	2737
18.	Cinmethylin + Imazaquin	1.1 + 0.071	0.0	22.8	2428
19.	Chlorimuron-ethyl	8.7 g	0.0	17.3	2535
20.	Chlorimuron-ethyl	17.5 g	0.0	17.0	2757
21.	Chlorimuron-ethyl	26.3 g	0.0	16.0	2751
22.	DPX-L8347	0.42	0.0	18.0	2710
23.	DPX-L8347	0.84	0.0	15.8	2683
24.	Standard		0.0	19.4	2562
	$LSD_{(.05)}$		0.6	3.2	525
	CV %		81.4	14.1	16.3

Table 44: 1987 Rossville wheat crop injury ratings, grain moisture, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Moisture (%)	Yield (kg/ha)
1.	Imazaquin	0.14	0.0	11.5	3423
2.	Imazaquin	0.28	0.0	11.1	3578
3.	Imazaquin	0.43	0.0	11.5	3329
4.	Imazaquin + Metribuzin	0.071 + 0.28	0.0	11.1	3443
5.	Imazethapyr	0.14	0.0	11.1	3073
6.	Imazethapyr	0.28	0.0	11.2	3389
7.	Imazethapyr	0.43	0.0	11.5	3356
8.	Imazethapyr + Imazaquin	0.071 + 0.071	0.0	10.9	3531
9.	Clomazone	1.1	0.0	11.4	3141
10.	Clomazone	2.2	0.3	11.3	3282
11.	Clomazone	3.4	1.7	11.1	3188
12.	Clomazone + Imazaquin	0.84 + 0.071	0.0	11.3	3295
13.	Clomazone + Metribuzin	0.84 + 0.28	0.0	11.1	3282
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	0.0	11.2	3289
15.	Cinmethylin	1.3	0.0	11.1	3544
16.	Cinmethylin	2.7	0.0	11.1	3531
17.	Cinmethylin	4.0	0.0	10.9	3463
18.	Cinmethylin + Imazaquin	1.1 + 0.071	0.0	11.5	3329
19.	Chlorimuron-ethyl	8.7 g	0.0	11.0	3463
20.	Chlorimuron-ethyl	17.5 g	0.0	11.1	3134
21.	Chlorimuron-ethyl	26.3 g	0.0	11.0	3423
22.	DPX-L8347	0.42	0.0	11.2	3235
23.	DPX-L8347	0.84	0.0	11.3	3155
24.	Standard		0.0	11.4	3127
	$LSD_{(.05)}$		0.2	NS	NS
	CV %		159.7	2.5	9.0

be discussed later as results are compared at other locations.

Grain Sorghum: Year 2 (Table 45)

No clomazone injury was observed in the grain sorghum. Similarly, imazethapyr carry-over injury was only slight and did not cause any difference in yield or grain moisture.

OTTAWA

Imazaquin will not be discussed at Ottawa because no carry-over injury from this herbicide was observed at Ottawa.

Grain Sorghum: Year 1 (Table 46)

Imazethapyr injury symptoms and results at Ottawa were very similar to Year 1 grain sorghum at Manhattan. Plants were severely stunted and yield dramatically reduced at the 2 and 3X rates. Grain moisture did not reflect any differences due to the late harvest dates, 12/30 and 12/31.

Clomazone at the higher 2 rates turned some sorghum leaves white, but plants soon grew out of it by the 7/18/86 rating date. Favorable growing conditions helped produce very good yields.

Grain Sorghum: Year 2 (Table 47)

At Ottawa resulting injury in Year 2 was almost identical to injury in Year 1. Some early clomazone injury at the highest 2 rates disappeared quickly. Imazethapyr injury was visually appraised as similar to the previous

Table 45: 1987 Rossville grain sorghum crop injury ratings, grain moisture, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Moisture (%)	Yield (kg/ha)
1.	Imazaquin	0.14	0.0	21.0	1837
2.	Imazaquin	0.28	0.0	21.6	2059
3.	Imazaquin	0.43	0.0	22.2	1447
4.	Imazaquin + Metribuzin	0.071 + 0.28	0.0	21.7	2226
5.	Imazethapyr	0.14	0.0	21.5	1745
6.	Imazethapyr	0.28	0.8	23.4	1632
7.	Imazethapyr	0.43	2.3	22.8	1468
8.	Imazethapyr + Imazaquin	0.071 + 0.071	0.0	20.7	2125
9.	Clomazone	1.1	0.0	21.1	2079
10.	Clomazone	2.2	0.0	22.2	2311
11.	Clomazone	3.4	0.0	22.8	1632
12.	Clomazone + Imazaquin	0.84 + 0.071	0.0	21.6	2209
13.	Clomazone + Metribuzin	0.84 + 0.28	0.0	21.8	2441
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	0.0	22.5	1821
15.	Cinmethylin	1.3	0.0	22.0	2458
16.	Cinmethylin	2.7	0.0	21.4	2463
17.	Cinmethylin	4.0	0.0	22.3	2527
18.	Cinmethylin + Imazaquin	1.1 + 0.071	0.0	22.2	2164
19.	Chlorimuron-ethyl	8.7 g	0.0	22.3	2630
20.	Chlorimuron-ethyl	17.5 g	0.0	20.7	2829
21.	Chlorimuron-ethyl	26.3 g	0.0	23.3	1766
22.	DPX-L8347	0.42	0.0	19.9	2208
23.	DPX-L8347	0.84	0.0	21.1	2110
24.	Standard		0.0	20.1	2282
	$LSD_{(.05)}$		0.2	NS	NS
	CV %		99.1	8.0	32

Table 46: 1986 Ottawa grain sorghum crop injury ratings, grain moisture, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Moisture (%)	Yield (kg/ha)
1.	Imazaquin	0.14	0.0	17.2	7099
2.	Imazaquin	0.28	0.0	17.4	7120
3.	Imazaquin	0.43	0.0	17.5	7331
4.	Imazaquin + Metribuzin	0.071 + 0.28	0.0	17.0	6910
5.	Imazethapyr	0.14	0.5	17.6	7182
6.	Imazethapyr	0.28	2.5	16.6	5284
7.	Imazethapyr	0.43	4.3	17.3	2995
8.	Imazethapyr + Imazaquin	0.071 + 0.071	0.3	17.0	6830
9.	Clomazone	1.1	0.0	17.5	6895
10.	Clomazone	2.2	0.0	17.0	6627
11.	Clomazone	3.4	0.0	17.0	6639
12.	Clomazone + Imazaquin	0.84 + 0.071	0.0	17.1	7041
13.	Clomazone + Metribuzin	0.84 + 0.28	0.0	17.7	7071
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	0.0	16.8	6695
15.	Cinmethylin	1.3	0.0	16.9	7120
16.	Cinmethylin	2.7	0.0	16.7	7392
17.	Cinmethylin	4.0	0.0	16.9	7317
18.	Cinmethylin + Imazaquin	1.1 + 0.071	0.0	17.1	7175
19.	Chlorimuron-ethyl	8.7 g	0.0	16.7	7558
20.	Chlorimuron-ethyl	17.5 g	0.0	16.8	7226
21.	Chlorimuron-ethyl	26.3 g	0.0	16.5	7046
22.	DPX-L8347	0.42	0.0	16.1	7310
23.	DPX-L8347	0.84	0.0	16.8	6489
24.	Standard		0.0	17.2	6627
	$LSD_{(.05)}$		0.2	NS	684
	CV %		52.3	3.6	7.3

Table 47: 1987 Ottawa grain sorghum crop injury ratings, grain moisture, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Moisture (%)	Yield (kg/ha)
1.	Imazaquin	0.14	0.0	15.9	2334
2.	Imazaquin	0.28	0.0	15.3	2187
3.	Imazaquin	0.43	0.0	14.9	2304
4.	Imazaquin + Metribuzin	0.071 + 0.28	0.0	15.0	2207
5.	Imazethapyr	0.14	0.0	15.8	2293
6.	Imazethapyr	0.28	2.7	16.5	1946
7.	Imazethapyr	0.43	5.3	18.0	957
8.	Imazethapyr + Imazaquin	0.071 + 0.071	0.0	15.1	2282
9.	Clomazone	1.1	0.0	15.4	2085
10.	Clomazone	2.2	0.0	15.4	2221
11.	Clomazone	3.4	0.0	15.7	2291
12.	Clomazone + Imazaquin	0.84 + 0.071	0.0	15.6	2241
13.	Clomazone + Metribuzin	0.84 + 0.28	0.0	14.7	2131
14.	Clomazone + Chlorimuron-ethyl	0.84 + 8.7 g	0.0	15.5	2126
15.	Cinmethylin	1.3	0.0	14.4	2151
16.	Cinmethylin	2.7	0.0	15.3	2113
17.	Cinmethylin	4.0	0.0	15.1	2192
18.	Cinmethylin + Imazaquin	1.1 + 0.071	0.0	15.7	2139
19.	Chlorimuron-ethyl	8.7 g	0.0	15.1	2096
20.	Chlorimuron-ethyl	17.5 g	0.0	15.2	2422
21.	Chlorimuron-ethyl	26.3 g	0.0	15.1	2028
22.	DPX-L8347	0.42	0.0	15.4	1983
23.	DPX-L8347	0.84	0.0	14.9	2191
24.	Standard		0.0	15.6	1967
	$LSD_{(.05)}$		0.2	0.9	339
	CV %		51.1	4.0	11.6

year. However, a hail storm on August 18, 1987, virtually destroyed an excellent sorghum crop. Yields shown are what was harvested from remaining plants. Yields still reflect significant yield reduction from imazethapyr carry-over injury. Grain moisture was significantly higher from the 2 highest rates of imazethapyr.

HESSTON

Wheat: Year 1 (Table 48)

Carry-over injury at Hesston occurred with all rates of imazaquin, imazethapyr, and clomazone. Imazaquin and imazethapyr injury was similar, but imazethapyr injury was more severe. Stunting and stand reduction increased in severity with increasing rates of these two compounds. Clomazone bleached wheat leaves and reduced stands 50 to 100%. Maturity of remaining plants in clomazone plots was delayed. More will be discussed later on why this site suffered such drastic carry-over.

Wheat: Year 2 (Table 49)

Imazaquin and imazethapyr injury was less severe than in the previous year. Only the 3X rate of imazethapyr reduced yields significantly. All rates of clomazone caused bleached leaves, stand reduction, and yield losses. Higher grain moisture and lower test weight reflect the delayed maturity of clomazone injured wheat at the 1X rate. The clomazone injury is similar in severity to that in the

Table 48: 1986 Hesston wheat crop injury ratings, grain moisture, grain test weight, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Moisture (%)	Test weight (kg/m^3)	Yield (kg/ha)
1.	Imazaquin	0.14	2.0	11.3	715	2850
2.	Imazaquin	0.28	4.0	12.0	695	2009
3.	Imazaquin	0.43	5.8	11.7	682	1470
4.	Imazaquin + Metribuzin	0.071 0.28	0.3	11.2	727	3175
5.	Imazethapyr	0.14	2.3	11.3	720	2584
6.	Imazethapyr	0.28	6.2	12.0	689	1327
7.	Imazethapyr	0.43	7.2	12.0	668	911
8.	Imazethapyr + Imazaquin	0.071 0.071	1.2	11.1	726	2644
9.	Clomazone	1.1	7.8	13.5	639	1268
10.	Clomazone	2.2	9.7	-	-	172
11.	Clomazone	3.4	10.0	-	-	0
12.	Clomazone + Imazaquin	0.84 0.071	4.7	11.4	718	2482
13.	Clomazone + Metribuzin	0.84 0.28	4.7	11.8	698	2398
14.	Clomazone + Chlorimuron-ethyl	0.84 8.7 g	4.5	11.2	716	2579
15.	Cinmethylin	1.3	0.0	11.2	730	3442
16.	Cinmethylin	2.7	0.0	11.2	731	3259
17.	Cinmethylin	4.0	0.0	11.1	732	3453
18.	Cinmethylin + Imazaquin	1.1 0.071	0.8	11.1	724	2940
19.	Chlorimuron-ethyl	8.7 g	0.0	11.0	729	3303
20.	Chlorimuron-ethyl	17.5 g	0.0	11.1	725	3131
21.	Chlorimuron-ethyl	26.3 g	0.0	11.1	730	3057
22.	DPX-L8347	0.42	0.0	11.3	727	3135
23.	DPX-L8347	0.84	0.0	11.1	727	3031
24.	Standard		0.0	11.0	722	2797
	$LSD_{(.05)}$		0.7	0.6	16	383
	CV %		16.8	4.0	1.7	11.8

Table 49: 1987 Hesston wheat crop injury ratings, grain moisture, grain test weight, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Moisture (%)	Test weight (kg/m^3)	Yield (kg/ha)
1.	Imazaquin	0.14	0.0	12.1	691	2880
2.	Imazaquin	0.28	0.3	12.0	683	2864
3.	Imazaquin	0.43	0.7	12.6	672	2683
4.	Imazaquin + Metribuzin	0.071 0.28	0.0	12.3	685	3116
5.	Imazethapyr	0.14	0.0	12.6	680	2909
6.	Imazethapyr	0.28	1.0	12.6	673	2593
7.	Imazethapyr	0.43	2.2	13.0	655	1860
8.	Imazethapyr + Imazaquin	0.071 0.071	0.0	12.3	686	3179
9.	Clomazone	1.1	7.2	17.3	595	1471
10.	Clomazone	2.2	9.3	-	-	0
11.	Clomazone	3.4	10.0	-	-	0
12.	Clomazone + Imazaquin	0.84 0.071	3.2	12.3	661	2205
13.	Clomazone + Metribuzin	0.84 0.28	4.3	13.4	639	1668
14.	Clomazone + Chlorimuron-ethyl	0.84 8.7 g	3.2	13.4	643	1808
15.	Cinmethylin	1.3	0.0	12.2	675	2986
16.	Cinmethylin	2.7	0.0	12.3	689	3128
17.	Cinmethylin	4.0	2.3	12.3	677	2329
18.	Cinmethylin + Imazaquin	1.1 0.071	0.0	12.4	689	3097
19.	Chlorimuron-ethyl	8.7 g	0.0	12.8	685	3106
20.	Chlorimuron-ethyl	17.5 g	0.0	12.3	686	3063
21.	Chlorimuron-ethyl	26.3 g	0.0	12.6	682	3079
22.	DPX-L8347	0.42	0.0	12.2	686	3001
23.	DPX-L8347	0.84	0.0	12.7	682	2996
24.	Standard		0.0	12.1	683	3024
	$LSD_{(.05)}$		1.3	0.8	17	525
	CV %		51.6	5.3	2.0	15.6

previous year's wheat plot. The crop injury with resulting yield reduction in treatment 17 was severe on the first replication and slight on the second replication. No injury or yield loss was observed on the third replication. Since the injury occurred mainly on one replication and no other cinmethylin injury was noted at any other plot, it is attributed to application error.

So, in comparison, imazaquin and imazethapyr injury was considerably less than the previous year, but clomazone injury was very similar in both years.

Grain Sorghum: Year 1 (Table 50)

In the grain sorghum plot, injury rating scores better reflect the relative amount of carry-over than do yields. Since no nitrogen fertilizer was added to the sorghum crop, sorghum used residual nitrogen that was applied to the wheat crop. Because different amounts of nitrogen were used by the wheat depending on the amount of carry-over injury to the wheat, the sorghum plots had differing amounts of nitrogen available for growth. As a result, some yields are low because there was little residual nitrogen, since uninjured wheat grew well and used most of the nitrogen available. Examples of this result are in cinmethylin and chlorimuron-ethyl plots where sorghum was uninjured from herbicide carry-over but yields were low due to nitrogen deficency. Other yields depended on available nitrogen and

Table 50: 1986 Hesston grain sorghum crop injury ratings, grain moisture, grain test weight, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Moisture (%)	Test weight (kg/m^3)	Yield (kg/ha)
1.	Imazaquin	0.14	1.2	19.7	657	4130
2.	Imazaquin	0.28	4.2	21.8	653	4080
3.	Imazaquin	0.43	2.8	20.3	668	4953
4.	Imazaquin +	0.071	1.2	22.3	647	3195
	Metribuzin	0.28				
5.	Imazethapyr	0.14	6.0	25.4	603	3321
6.	Imazethapyr	0.28	7.7	27.3	588	1481
7.	Imazethapyr	0.43	8.8	27.4	562	1124
8.	Imazethapyr +	0.071	3.8	23.0	630	3013
	Imazaquin	0.071				
9.	Clomazone	1.1	5.5	22.3	642	3314
10.	Clomazone	2.2	8.5	23.4	619	2699
11.	Clomazone	3.4	9.7	25.5	584	615
12.	Clomazone +	0.84	1.2	20.4	659	3747
	Imazaquin	0.071				
13.	Clomazone +	0.84	3.0	20.1	666	3823
	Metribuzin	0.28				
14.	Clomazone +	0.84	2.7	20.8	660	3365
	Chlorimuron-ethyl	8.7 g				
15.	Cinmethylin	1.3	0.0	20.4	657	2731
16.	Cinmethylin	2.7	0.0	19.9	662	3371
17.	Cinmethylin	4.0	0.0	19.7	666	3823
18.	Cinmethylin +	1.1	0.0	21.0	651	3101
	Imazaquin	0.071				
19.	Chlorimuron-ethyl	8.7 g	0.0	20.7	656	2881
20.	Chlorimuron-ethyl	17.5 g	0.0	22.5	650	2649
21.	Chlorimuron-ethyl	26.3 g	0.0	22.1	646	2743
22.	DPX-L8347	0.42	0.0	22.0	645	2718
23.	DPX-L8347	0.84	0.0	22.2	651	2366
24.	Standard		0.0	22.3	633	2316
	$LSD_{(.05)}$		1.1	2.1	23	973
	CV %		24.0	5.7	2.2	19.9

injury to the sorghum crop. The 2 highest rates of clomazone still caused greatly reduced sorghum yields due to herbicide injury. These 2 treatments and the 1 X rate of imazethapyr delayed maturity, which resulted in higher grain moisture and reduced test weights.

Grain Sorghum: Year 1 (1987) (Table 51)

Because of the considerable herbicide residue still present in this sorghum plot at Hesston, grain sorghum was planted again in 1987 to evaluate carry-over into a second year. Injury ratings and yields still show the same carry-over injury as previously described. The highest 2 rates of imazethapyr and highest rate of clomazone still reduced yields dramatically. Grain moistures and test weights were affected by these treatments in the same ways, thus reflecting the delayed maturity of the sorghum in these plots.

Grain Sorghum: Year 2 (Table 52)

Imazethapyr carry-over was similar in severity to the 1986 Year 1 sorghum at Hesston. Plants were stunted, stands were reduced, yields dramatically decreased, grain test weights were reduced, and moisture contents increased from the application of imazethapyr at all rates. Slight visual injury in 3X plots of imazaquin, caused a small significant yield reduction as compared to the 1X rate.

Table 51: 1987 Year 1 Hesston grain sorghum crop injury ratings, grain moisture, grain test weight, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Moisture (%)	Test weight (kg/m^3)	Yield (kg/ha)
1.	Imazaquin	0.14	0.0	15.9	713	7354
2.	Imazaquin	0.28	0.0	15.1	712	6067
3.	Imazaquin	0.43	0.5	16.0	689	6428
4.	Imazaquin + Metribuzin	0.071 0.28	0.0	15.4	709	6134
5.	Imazethapyr	0.14	1.7	18.0	639	5270
6.	Imazethapyr	0.28	5.3	22.8	567	2676
7.	Imazethapyr	0.43	7.5	25.1	528	1594
8.	Imazethapyr + Imazaquin	0.071 0.071	0.8	14.8	686	4614
9.	Clomazone	1.1	0.0	15.1	705	5496
10.	Clomazone	2.2	2.7	15.8	678	5327
11.	Clomazone	3.4	3.7	18.6	640	4064
12.	Clomazone + Imazaquin	0.84 0.071	0.0	14.7	722	6393
13.	Clomazone + Metribuzin	0.84 0.28	0.0	15.0	711	6543
14.	Clomazone + Chlorimuron-ethyl	0.84 8.7 g	0.0	14.9	714	5669
15.	Cinmethylin	1.3	0.0	15.0	714	6031
16.	Cinmethylin	2.7	0.0	15.0	723	6723
17.	Cinmethylin	4.0	0.0	14.9	719	6288
18.	Cinmethylin + Imazaquin	1.1 0.071	0.0	14.9	718	6435
19.	Chlorimuron-ethyl	8.7 g	0.0	15.0	713	5572
20.	Chlorimuron-ethyl	17.5 g	0.0	14.8	717	5779
21.	Chlorimuron-ethyl	26.3 g	0.0	14.7	710	5890
22.	DPX-L8347	0.42	0.0	14.8	708	5918
23.	DPX-L8347	0.84	0.0	14.7	706	5425
24.	Standard		0.0	15.2	687	4999
	$LSD_{(.05)}$		1.2	2.0	36	1356
	CV %		98.3	8.9	3.8	17.9

Table 52: 1987 Year 2 Hesston grain sorghum crop injury ratings, grain moisture, grain test weight, and yields.

No.	Herbicide Treatment	Kg A.I. per Ha	Crop Injury	Moisture (%)	Test weight (kg/m^3)	Yield (kg/ha)
1.	Imazaquin	0.14	0.0	23.5	381	1354
2.	Imazaquin	0.28	0.0	22.7	369	1203
3.	Imazaquin	0.43	0.3	24.0	352	1046
4.	Imazaquin +	0.071	0.0	22.7	375	1184
	Metribuzin	0.28				
5.	Imazethapyr	0.14	5.0	26.6	310	333
6.	Imazethapyr	0.28	7.0	28.0	278	156
7.	Imazethapyr	0.43	8.7	26.2	323	177
8.	Imazethapyr +	0.071	2.3	24.5	332	882
	Imazaquin	0.071				
9.	Clomazone	1.1	0.0	23.2	401	1565
10.	Clomazone	2.2	1.7	23.3	345	1183
11.	Clomazone	3.4	3.3	24.0	310	939
12.	Clomazone +	0.84	0.0	22.7	409	1513
	Imazaquin	0.071				
13.	Clomazone +	0.84	0.0	23.1	397	1339
	Metribuzin	0.28				
14.	Clomazone +	0.84	0.0	23.6	365	1364
	Chlorimuron-ethyl	8.7 g				
15.	Cinmethylin	1.3	0.0	22.9	362	1137
16.	Cinmethylin	2.7	0.0	22.8	348	1085
17.	Cinmethylin	4.0	0.0	23.2	360	1241
18.	Cinmethylin +	1.1	0.0	23.3	390	1290
	Imazaquin	0.071				
19.	Chlorimuron-ethyl	8.7 g	0.0	22.7	350	1192
20.	Chlorimuron-ethyl	17.5 g	0.0	23.3	347	1124
21.	Chlorimuron-ethyl	26.3 g	0.0	24.1	370	1158
22.	DPX-L8347	0.42	0.0	22.4	381	1224
23.	DPX-L8347	0.84	0.0	23.0	367	1186
24.	Standard		0.0	23.1	374	1254
	$LSD_{(.05)}$		0.5	1.1	40	239
	CV %		31.8	3.4	8.1	16.0

However, the clomazone carry-over injury was considerably less compared to the 1986 site. Some stand loss was observed at the 2X and 3X rates, but no injury could be seen at the lower rates. The higher 2 rates did cause a yield reduction and lowered grain test weight.

Yields were poor and test weights were low on this site because of the late (July 10) planting date and an early (October 3) frost.

<u>Factors Influencing Carry-over</u>

Since the carry-over from clomazone and imazethapyr can be quite striking, causing yield reductions of up to 100%, identifying factors that contribute to the differences in herbicide carry-over would be beneficial. Carry-over injury to grain sorghum from imazethapyr and to wheat from clomazone is of primary concern.

Table 53 lists pH, organic matter, and clay content for each site. Listed also is the yield reduction and crop injury resulting from carry-over of the 3 X rate of imazethapyr. The sites have been arranged in order of decreasing severity of the carry-over injury to both crops based upon visual observations and analysis of the data. To justify the order of ranking, I would like to point out the following factors which were previously mentioned. Grain sorghum at the year 1 Hesston site did not have any nitrogen fertiizer, and year 2 Hesston yields were extremely low due

Table 53: Comparison of pH, OM, and clay content to crop injury ratings and yield reductions from imazethapyr carry-over at each location.

Location[1]	Year	pH	OM	% clay[2]	Yield Reduction GS	Yield Reduction Wheat	Crop injury[4] GS[5]	Crop injury[4] Wheat
Hesston	1	5.5	1.9	34	78%	74%	8.8	7.2
Hesston	2	6.0	2.2	15-27	89%	41%	8.7	2.2
Manhattan	1	6.7	2.0	25	64%	14%	6.7	2.2
Ottawa	1	6.0	2.9	20	60%	-	4.3	-
Ottawa	2	6.5	3.2	20	61%	-	5.3	-
Manhattan	2	6.7	2.0	25	39%	NS	3.3	0.5
Rossville	2	7.4	1.1	<15[3]	NS	NS	2.3	0.0

[1]The sites are put in order of decreasing severity of carry-over based upon the author's visual observations and analysis of data in order to identify factors responsible for differences in carry-over.

[2]Clay content typically in the A horizon(33, 34)

[3]Estimate of M.D. Ransom, Kansas State University.

[4]Yield reduction and crop injury ratings are from the 3X rates of imazethapyr.

[5]GS = Grain sorghum

Wheat was not planted both years at the Ottawa site.

to late planting and early frost. For these reasons, visual observations and the wheat yield reductions were used to determine that carry-over was greater in year 1 rather than year 2, even though grain sorghum yield reductions do not indicate this. Also, Ottawa year 2 grain sorghum yield reduction reliability can be questioned due to the hail that nearly destroyed the crop. Excluding these exceptions, severity of carry-over between sites was ranked on the basis of grain sorghum yield reduction. By comparing the differences in pH, OM, and clay content, it appears soil texture and pH could have an effect on severity of imazethapyr carry-over. Other lab and field studies have researched possible soil factors that could influence imazethapyr and imazaquin carry-over. Only soil texture could be shown to conclusively affect persistence of these herbicides in the soil. Bashan(4), Loux(21), and Renner(29) all found that finer textured soils have caused greater imazethapyr carry-over. So, based upon these findings and my own in this study, I would conclude that soil texture plays a major role in influencing the amount of imazethapyr carry-over.

Table 54 ,in the same manner, shows clomazone carry-over injury at each location and the same 3 soil factors. With clomazone, the sites are easliy arranged in order of decreasing carry-over injury. By examining the 3

Table 54: Comparison of pH, OM, and clay content to crop injury ratings and yield reductions from clomazone carry-over at each location.

Location[1]	Year	pH	OM	% clay[2]	Yield Reduction Wheat	Yield Reduction GS[5]	Crop injury[4] Wheat	Crop injury[4] GS
Hesston	1	5.5	1.9	34	100%	90%	10.0	9.7
Hesston	2	6.0	2.2	15-27	100%	52%	10.0	3.3
Rossville	1	6.0	1.4	11	100%	-	9.2	-
Manhattan	1	6.7	2.0	25	25%	NS	5.8	3.0
Manhattan	2	6.7	2.0	25	NS	NS	6.0	0.2
Rossville	2	7.4	1.1	<15[3]	NS	NS	1.7	0.0

[1]The sites are placed in order of decreasing severity of carryover based upon author's visual observations and data analysis in order to identify factors responsible for differences in carry-over.

[2]Clay content typically in the A horizon(33, 34)

[3]Estimate of M.D. Ransom, Kansas State University.

[4]Yield reduction and crop injury ratings are from the 3 X rate of clomazone.

[5]GS = Grain sorghum

Grain sorghum was not planted in the Rossville year 1 site.

soil factors, I can strongly suggest that pH influenced the severity of carry-over. As pH increases, the amount of carry-over injury dramatically drops. This is strongly supported by looking at the 2 Rossville sites. Both soils have a low clay content and low organic matter. As mentioned earlier, the sites are located close together in the same field. Visually, the soils appear to have similar high sand contents, even though Year 1 site is mapped as a silt loam and year 2 site is mapped as a fine sandy loam. Considering the similarity in OM and soil texture, notice that year 1 showed a 100% wheat yield reduction and year 2 yields were unaffected. In comparing the pH differences, 6.0 for year 1 and 7.4 for year 2, we can conclude that pH and persistence of clomazone have a strong negative relationship. Furthermore, this relationship is seen throughout the 2 years at the 3 different locations growing wheat. Injury data from grain sorghum also supports this conclusion. The clomazone label states that pH below 6.0 can cause greater potential for carry-over injury, which supports the findings of this study.

GREENHOUSE

No differences could be visually observed between the 41 cultivars evaluated for tolerance to clomazone. All

wheat leaves appeared to be bleached approximately 50%. Therefore, the greenhouse experiment was discontinued after one evaluation.

CONCLUSIONS

From the results of this study several definite conclusions can be made.

Weed Control

Imazaquin and imazethapyr show promising activity on puncturevine, a weed presently not controlled PE. Imazethapyr has greater grassy weed activity than imazaquin as shown by better control of fall panicum and crabgrass sp. in this study. Clomazone will not control pigweed sp. and carpetweed alone; so another herbicide will need to be tank-mixed with clomazone for control of these weeds.

Crop Safety

Imazaquin and imazethapyr have the potential to stunt soybeans in light soils and at higher-than-normal rates, but overall have good crop safety. Clomazone has demonstrated up to a 3 X margin of safety. Cinmethylin can stunt soybeans, but in most cases does not cause a yield reduction. Chlorimuron-ethyl applied PE also has a slight potential to stunt soybeans, but little potential to reduce yields at these rates.

Herbicide Carry-over

Imazaquin can injure and reduce yields of rotational wheat and grain sorghum planted within 1 year of application

on fine-textured soils. However, under most conditions herbicide carry-over to these rotational crops should not be a problem. These conclusions support the already approved label recropping interval of 4 months for wheat and 11 months for grain sorghum.

Imazethapyr has the potential in most situations, to cause carry-over injury and yield reduction to grain sorghum 1 year after application, and even for 2 years on fine-textured soils. Also with fine-textured soils, wheat can be dramatically injured by imazethapyr residues.

Amount of clomazone carry-over is greatly affected by soil pH. So in low pH soils, clomazone residue can injure wheat and grain sorghum one or more years after application. Wheat is especially sensitive to clomazone. The greenhouse study showed that there was not any difference between wheat cultivars in their tolerance to clomazone. Carry-over injury to wheat planted the same year of clomazone application can be expected under most conditions. These results strongly support the label recropping intervals of 9 months for grain sorghum and over 1 year for wheat. Furthermore, soils with pH less than 6.0, may need longer recropping intervals as stated on the label.

Cinmethylin and chlorimuron-ethyl present no wheat and grain sorghum recropping problems under weather and soil conditions in this study.

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ROTATIONAL CROPPING AFTER APPLYING EXPERIMENTAL HERBICIDES FOR WEED CONTROL IN SOYBEANS

by

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AN ABSTRACT OF A THESIS

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Imazaquin, imazethapyr, clomazone, cinmethylin, and chlorimuron-ethyl, new soybean [Glycine max (L.) Merr.] herbicides, were evaluated for weed control, crop safety, and carry-over potential to rotational hard red winter wheat (Triticum aestivum L.) and grain sorghum [Sorghum bicolor (L.) Moench]. The 2 year study was conducted at 4 locations in east and central Kansas, all varying in weather and soil conditions. Each herbicide was applied at 1, 2, and 3 times the expected label usage rate and at a reduced rate in combination with other herbicides. Twenty-four herbicide treatments, including a standard treatment of alachlor + metribuzin, were applied preemergent to soybeans in 1985 and 1986. Excellent puncturevine (Tribulus terrestris L.) control was noted at one location in 1985 with imazaquin and imazethapyr applications. Cinmethylin stunted soybeans but in most cases did not reduce yields.

Following soybean harvest, wheat was planted in October and/or grain sorghum was planted in June or July to evaluate herbicide carry-over. Imazaquin did not cause significant carry-over injury except on fine-textured soils. Imazethapyr at 3X rates reduced grain sorghum yields 39 to 89%. Imazethapyr at 3X rates reduced wheat yields 74% on fine-textured soil; however it did not cause any injury on coarse-textured soil. Clomazone residue injured and reduced wheat yields from 0 to 100%. Soil pH appeared to be the

most significant factor affecting the amount of carry-over injury to wheat and grain sorghum. On a low pH soil, yields of double-cropped grain sorghum planted 12 months after application were reduced up to 90%. Cinmethylin and chlorimuron-ethyl did not cause any carry-over injury. In a greenhouse study, no difference was found between wheat cultivars in their tolerance to clomazone.